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Report of the Defense Science Board Task Force on Environmental Security

April 22, 1995

Office of the Under Secretary of Defense, Acquisition and Technology

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Defense Science Board

Office of the Under Secretary of Defense for Acquisition and Technology
Washington, D.C. 20301-3140

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE (ACQUISITION AND TECHNOLOGY)

Subject: Report of the Defense Science Board (DSB) Task Force on Environmental Security

I am pleased to forward the final report of the DSB Task Force on Environmental Security. Dr. Jacques S. Gansler, Task Force Chairman, led a distinguished panel, composed of both members of the Defense Science Board and outside experts, who were assisted by an outstanding inter-departmental group of government advisors. Throughout the deliberations of the Task Force, there was also a very close working relationship between the Office of the Deputy Under Secretary of Defense (Environmental Security) (DUSD(ES)) and the Task Force. This included a two-day, DoD-wide offsite meeting hosted by the DUSD(ES) which reviewed the Interim Report of the Task Force and made valuable suggestions.

During the brief life of this Task Force, the mood of the Government has shifted significantly in the environmental security area, and we are now in a situation in which environmental programs and activities have come under close scrutiny by many within the Legislative and Executive Branches. Yet, the Task Force found that environmental security is becoming increasingly significant to DoD activities -- impacting both costs and military readiness. Thus, from both perspectives, the recommendations of this Task Force, for a proactive DoD position in improving its management of environmental security, become even more important.

The Task Force identified seven specific areas where there are significant opportunities for improvement. I fully concur with the findings of the Task Force and recommend that you, and the other leaders of the DoD, aggressively pursue the implementation of the Task Force recommendations. Without such senior leadership, the impact of environmental security on the DoD's costs and readiness is likely to grow significantly in the future.

Dr. Craig I. Fields
Chairman
Defense Science Board

Attachment

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

Subject: Report of the Defense Science Board (DSB) Task Force on Environmental Security

Attached is the Report of the DSB Task Force on Environmental Security. This report assesses the environmental security activities of the Department of Defense (DoD) and makes recommendations for improvements in the areas of cleanup, compliance, pollution prevention, and natural resource conservation.

The Task Force found cause for considerable concern about the rising costs to satisfy the DoD's mandated environmental requirements, as well as the impact that growing environmental demands are likely to have on future force readiness. The Task Force believes that, without significant change in the DoD's approach to environmental security, and with the likely future restrictive budgets and growing resource needs, the Department may not be able to satisfy its environmental commitments in a timely fashion. Thus, environmental security will become an increasingly critical issue for the DoD.

However, the Task Force believes that there is clear evidence to indicate that, if corrective actions are initiated immediately, DoD's environmental requirements can be met in the future, at lower costs and with far less impact on military readiness. The Task Force identified seven areas for significant improvement and described specific actions to be taken in each of these areas.

As the largest consumer of goods in the United States, one of the largest land managers, and a major operator of facilities and bases, the DoD has both the need and the obligation to take a leadership role in those environmental security areas that impact its operations and costs. Also, it must work closely with regulators and community stakeholders to ensure their participation and gain their support. Through such a proactive management approach, and with implementation of the specifics of the Task Force's seven sets of actions, the DoD can significantly strengthen its national security mission over the long term.

Dr. Jacques S. Gansler
Chairman
DSB Task Force on Environmental Security

Preface

At the request of the Under Secretary of Defense (Acquisition & Technology), the Defense Science Board (DSB) formed a Task Force to conduct an assessment of the environmental security activities of the Department of Defense (DoD) and make recommendations for improvements. This Task Force was charged to investigate areas of technology and policy changes that could have a dramatic impact on future Department of Defense environmental security in the four areas of cleanup, compliance, pollution prevention and natural resource conservation.

The Terms of Reference for this Task Force are attached as Appendix A to this report. The members and government advisors of this Task Force are listed on page numbers 3 and 4 respectively. The Task Force was requested to compile representative historic examples of the strengths and weaknesses of ongoing DoD environmental programs and initiatives and to recommend improved strategies and specific plans of action to implement a strong and cost-effective environmental security program. In its review of existing programs and policies, the Task Force was also charged to consider the activities of other agencies, as well as procedural or legislative issues that could impact rapid and effective environmental security program implementation.

The approach used by the Task Force in preparing this report was to receive numerous information briefings and other data from relevant experts within DoD, other government agencies, industry and public policy groups involved with defense environmental security (during the period of September through December, 1994), and then to formulate the Task Force's view of the most important goals for enhancing DoD environmental security. The Task Force efforts then focused on each of the identified goals in terms of the most promising areas for improvement, specific opportunities available to the Department and specific recommendations. The briefings provided to the Task Force are listed in Appendix B. Appendix C lists and defines acronyms used within this report. Appendix D discusses a case study which demonstrates the applicability of computer modeling and simulation to environmental security issues.

The enclosed report consists of an eight page narrative Executive Summary, a main report in viewgraph format, facing page text, in those cases where the viewgraphs themselves require further elaboration, and four appendices.

Table of Contents

Executive Summary

Opportunities and Challenges. The Department of Defense (DoD) is the largest customer for goods in the United States, one of the largest land managers and a major operator of facilities and bases. Therefore, DoD's policies can have a substantial impact, both positive and negative, on the environment throughout the country. The Department's major mission is to protect the nation and its interests throughout the world. Meeting environmental requirements is an important, but corollary obligation -- similar in nature to the environmental management role in industrial operations, whose major mission is to produce goods and services.

This Defense Science Board Task Force is concerned about both the rising costs and the barriers to readiness, exemplified by restrictions on training and vessel mobility, caused by environmental requirements. Since a primary requirement for any society must be to defend itself, the Task Force needed to determine what strategy would best suit this objective, while meeting other national priorities, such as environmental quality. The Task Force concluded that the Department must not only meet its legally required responsibilities, but because of its size and importance should also provide leadership in certain environmental areas that directly impact the DoD. By doing so, the Task Force believes that the DoD can strengthen its defense mission over the long term.

Almost all premier private sector firms are providing environmental leadership. They are finding opportunities for cost savings through prudent environmental management, technology investments, and pollution prevention. They are also involving local and state stakeholders in their decisions. This proactive management approach is not pursued for altruistic reasons. The management of these companies are convinced that they can reduce environmental costs in the long run, have greater flexibility in their operations and, hence, gain competitive advantages through such an approach.

The Task Force believes that the Department faces a similar set of decisions. If the DoD takes a proactive, leadership position -- working with stakeholders, pursuing new technology and pollution prevention, leveraging its buying power, and pursuing the most significant risks first -- it will be in a much stronger position to assure US national security interests. Public support in the communities in which the Department operates will be key to preserving operational flexibility. Moreover, there is little doubt that the DoD will ultimately need to meet environmental requirements. The Task Force believes that it will be cheaper in the long run to meet its requirements in a proactive fashion than to be forced to do so through protracted regulatory proceedings at the state and local levels.

DoD's Worsening Budget Dilemma. In recent years, the Department's investment in environmental security has been sizable: a direct annual investment of over $5 billion and about $2 billion of additional defense industry costs absorbed annually (see Page 9). Even at this level of investment, it is difficult to satisfy all local, state and federal regulatory requirements in a timely fashion. DoD now faces an increasing requirement for environmental dollars, particularly in the cleanup area. It is just now shifting from *study* to *cleanup* and this shift will further raise costs. Additionally, BRAC-95 funds have not yet been included in the DoD budgetary plans. A recent Congressional Budget Office

(CBO) report states that: *"DoD will probably need additional funds beyond those in the current budget plan to continue to meet the program's objectives...legislative relief may be required..." (January 1995).* The recent Congressional FY95 recisions only compound the problem. Thus, at a minimum, the DoD needs a rational way to set priorities.

The demand for more resources is coupled with projections of shrinking environmental budgets. The Task Force has identified several initiatives aimed at achieving the DoD environmental needs at lower costs. Specifically:

- Comparative risk reduction prioritization of investments
- A focus on implementation of pollution prevention actions
- More rapid validation and deployment of new commercial technology for DoD use
- Investment in early development and deployment of emerging technology aimed at defense-unique requirements
- Greater efficiency and effectiveness of environmental management (do more with less funding)
- Adjustments in environmental legislation (e.g., regarding land-use, timing, etc.) -- consistent with risk reduction priorities
- Stability of funding (for the next five years at $5B/yr)

Impact on Readiness. DoD is one of the largest landowners in the United States (> 25 million acres). With overseas areas increasingly restricted and with longer range weapons needs, the requirement for domestic air, land and water for training, testing and operations is growing. At the same time, conservation demands are increasingly restricting DoD's domestic land, air and water activities. Specifically, with regard to the impact of environmental concerns and regulation on military readiness, the Task Force found a large number of examples of potential readiness impacts. For example:

- Limitations imposed on Air Force use of ranges (test and training).
- Constrained naval operations caused by differing oil discharge standards in US waters (harbors, rivers and coastal regions).
- Constraints on use of military aircraft and ground support vehicles (e.g., California air quality standards).
- Reduction of Navy's ability to use sonar devices in tests and exercises because of the potential adverse effect on marine mammals.
- Limitations on Army armored vehicle maneuvers on training ranges that are habitats of threatened or endangered species (e.g., desert tortoises).
- Tightening advanced ship solid waste discharge standards (national and international) impacting naval operations.

The Task Force believes that a proactive DoD approach to future conservation issues is required today. If DoD is perceived as a good steward of the lands, especially at the local level, it will likely retain greater flexibility for its operations and training.

In summary, environmental security is clearly growing as a DoD issue area, and initial steps have been taken in the right direction; however, the Task Force finds a *lack of a DoD-wide system for setting priorities and for confronting the issues head-on*. Without change, DoD will not be capable of addressing its high risk environmental needs; will make inefficient and ineffective investments in environmental security, with its scarce resources; will continue to use outdated technology; and, as a result, will face increased environmental threats to military force readiness.

Significantly, with restrictive budgets and growing resource needs, the DoD will not be able to satisfy its environmental commitments in a timely fashion. There is clear evidence that better results are achievable. The DoD must set goals and establish metrics to measure accomplishments against such goals through the year 2000. Specific actions must be initiated today in order to achieve these objectives.

Specific Actions. The Task Force has identified seven opportunities that offer the potential for significant improvements in the DoD environmental security program. In order to capitalize on these opportunities, the Task Force makes the following recommendations:

1. A Management Program of Cleanup, Compliance, Pollution Prevention And Conservation Projects Based On Comparative Risk Reduction. DoD environmental security funding will not be sufficient to fully satisfy all cleanup, compliance, pollution prevention and conservation requirements in a timely manner. DoD's current reactive, case-by-case approach often fails to address highest risks first. A resource-constrained, comparative-risk-reduction management solution is required to set priorities. DoD must evaluate the risk reduction potential and costs associated with its various investments across the spectrum of activities and make decisions based on the greatest overall return. To fully implement such an approach will require close cooperation with regulators and other stakeholders (particularly at the local level).

Recommendations

- Institute a comparative risk reduction approach for budget planning in cleanup, compliance, pollution prevention and conservation, during the FY 1997 budgeting process:
  - Initially, implement a qualitative approach based on management and stakeholder judgments.
  - Strive for quantitative data wherever such data is available (e.g., in the cleanup area).
  - Actively pursue involvement with stakeholders through advisory boards (including federal, state and local regulators).
  - Over time, develop credible, understandable quantitative evaluation tools and databases for showing the comparative risks, cost-effectiveness, and times associated with alternative cleanup, compliance, pollution prevention, and conservation efforts.
- Develop an overall implementation plan to reduce the most serious risks and to tackle projects with greatest potential for risk reduction, given available resources.
- Evaluate the critical drivers for risks associated with DoD environmental security; particularly land-use and time to achieve compliance or cleanup.
- Greatly expand the use of modern modeling and simulation tools and techniques applied to environmental problems (see pages 27 and 28 for an example of the potential benefits).
- Push for consistent national and international standards in areas affecting DoD operations (e.g., ship discharges) to reduce environmental risks without impeding military operational flexibility.

2. Increasing Focus on Pollution Prevention. Pollution prevention is the reduction or elimination of pollution generation through substitution of inputs, process changes and better housekeeping. The Task Force finds too little emphasis on pollution prevention, even though it has demonstrated significant returns on investment. The result is

that pollution prevention projects are underfunded during budget tradeoffs. Today, there are insufficient incentives for cost-reducing, longer term investments.

Recommendations

- To establish incentives and new budget mechanisms for increased investment in pollution prevention:
  - Strengthen the commitment of senior officials to emphasize the value added from preventing pollution.
  - Incorporate pollution prevention criteria into research, development, test, evaluation, production, operations, maintenance/support and disposal program investment policies in the DoD planning, programming and budgeting process.
  - Significantly increase RDT&E, production, and maintenance program investments in pollution prevention -- phase in such increases over a six year period.
  - Allocate an additional $100M/yr for pollution prevention initiatives (to appropriate Military Service programs).
  - Work with the defense industry to facilitate (and incentivize) investments in pollution prevention.
  - Encourage pollution prevention as a mechanism for achieving compliance.
  - Allow local commands to use net savings from pollution prevention investments for other initiatives.
  - Use non-appropriated funds (e.g., from recycling) and defense business operational funds to incentivize pollution prevention.
- Develop and use result-oriented metrics and benchmarking to monitor progress and manage pollution prevention programs.
  - Establish demanding goals, relate goals to investments, set the levels for individual performers, and monitor progress.

3. <u>Accelerating Technology Development and Deployment</u>. Many existing cleanup technologies offer significant risk and/or cost reduction potential that is not currently being realized; due, in significant part, to institutional inertia and regulatory barriers. Many DoD problems are identical to those of the public and private sectors and are amenable to treatment by technologies developed outside DoD (see page 32). There are, however, some DoD-unique environmental problems requiring development of new technologies by DoD (see Page 33) and there are numerous technologies for early exploitation (see Pages 35 and 36).

In both categories (i.e., of commercial and DoD-unique), there is a need to significantly reduce the timeframe for environmental technology demonstration, validation and application. The biggest bottleneck today is in the <u>early deployment</u> of new technology. Technology demonstrations can be an important part of DoD's process for achieving more rapid verification and deployment of the most promising technologies. There is also a concern that, with shrinking budgets, sufficient environmental science and technology investments will not be made that could dramatically reduce future costs.

Recommendations

- Devote an additional $150M/yr for accelerated environmental technology demonstration and deployment:

  - Support current DoD and national environmental technology demonstration programs
  - Establish an additional 50 - 100 cleanup sites focused on accelerating the transition of promising environmental technologies into practice
  - Allocate the additional $150 million, through a Military Service-managed Joint Program Office, to manage the environmental technology demonstration and deployment effort
  - Establish data protocols, standardized reporting and a means to rapidly disseminate results
  - Focus resources on demonstrating and validating relevant commercial industry cleanup technology to the maximum extent possible
  - Encourage effective approval coordination among the states for technologies demonstrated under this program
  - Implement a DoD approach for accepting liability for new technology demonstrations and applications similar to that of DOE; explore need for new liability legislation
- Open DoD sites for technology demonstration and verification of technologies
  - Assure regulatory participation
- Prioritize and focus DoD technology investments on high potential environmental technologies that target high risk or high cost problems experienced by the DoD
  - Areas where insufficient commercial effort is taking place
- Expand on existing cooperation among agencies and departments and with industry, to seek maximum leverage for DoD investments
- Develop a set of incentives (e.g., extra resources, merit bonuses, etc.) for government site directors to utilize new technologies
- Urge EPA to develop measures to encourage/empower site managers to approve the use of innovative technologies when appropriate (senior managers in both agencies must be involved)
- Maintain the environmental science and technology budget at current levels, as a minimum
  - Proof of principle and field demonstration efforts are a critical element of DoD investments
- Develop procurement incentives that encourage the early deployment of promising technologies (e.g., procure performance of a function or job rather than the current procurement practice of buying environmental services based on labor hours and rates)
  - Pursue management initiatives (see Page 38)
- Reevaluate the roles of various participants in DoD environmental technology programs (DoD and national laboratories, industry and academia) to determine whether the resources are being allocated to the most effective performers
  - This needs independent review of all performers to ensure that only the best performers are funded

4. <u>Integrating Environmental Considerations into Weapons Systems Life Cycles (R&D to Disposal).</u> Approximately 80% of environmental costs (associated with hazardous wastes) relate to weapon systems' life cycle costs, including those at military bases (per the DoD Inspector General). For this reason, the Task Force focused attention on the weapon system acquisition process. DoD must identify and integrate environmental issues (including pollution prevention) into all

aspects of the life cycle for systems and components (R&D to disposal). Commercial experience has clearly demonstrated that *front end* design for a system's life cycle pays big rewards. Acquisition practices of the Department should adopt appropriate commercial, best environmental practices. This should be a subset of the DoD initiative in "acquisition reform."

Recommendations

- Integrate pollution prevention into the acquisition life cycle decision process through procedural changes (for new systems, system modifications, and existing systems; including maintenance and provisioning)
  - Require environmental expertise on integrated product-process teams
  - Establish goals to educate the acquisition workforce in environmental considerations
  - Ensure that needed investments are funded
  - Pursue management initiatives (see Page 44)
- Strengthen acquisition and support processes to promote cost-effective environmental practices
  - Make environmental considerations a normal part of DoD's life cycle process
  - Pursue personnel training and assignment policies that provide environmentally knowledgeable personnel
  - Investigate changes to the Defense Business Operations Fund (DBOF) and other capitalization sources to provide incentives to fund pollution prevention initiatives
- Develop and advocate streamlined federal environmental review processes for weapon systems
  - Otherwise, as weapons acquisition processes are streamlined, the environmental review process will hinder the deployment schedule
- Intensify DoD efforts toward achieving uniform national and international environmental standards in areas affecting many DoD operations
- Develop credible life cycle costing (LCC) tools and databases that:
  - Focus on rapid development of usable models
  - Incorporate predicted environmental costs, risks and performance
  - Achieve better ways for accounting for the cost savings associated with pollution prevention
  - Pursue management initiatives (see Page 44)

5. <u>Assuring Efficient and Effective Implementation Through Benchmarking and Appropriate Metrics</u>. The Task Force found that little quantitative data is currently available to compare DoD implementation with other Agencies (e.g., EPA, DOE) or, particularly, with commercial or international best practices. In each area of environmental security, goals need to be established and implementation results measured over time. Congress needs to be assured that environmental security appropriations are being spent efficiently and effectively.

Recommendations

- Initiate a benchmarking effort to compare DoD implementation with that of EPA, DOE, commercial industry and foreign practices
  - Pick specific non-DoD-unique environmental cleanup sites to start such an effort (e.g., hazardous waste sites)
  - Relate metrics to managers' ability to achieve them

- Analyze the differences between best practices and current practices.

- Define a continuing, DoD-wide process for:
  - Benchmarking
  - Defining metrics
  - Setting goals
  - Measuring progress toward goals and rewarding managers

6. **Developing a DoD Proactive Focus on Natural and Cultural Resource Conservation Affecting Military Readiness**. Readiness requirements include large areas of land, airspace, harbors and coastal areas for training, testing, and operations. Force modernization and changing geopolitical considerations are increasing the requirement for domestic activities in these areas (e.g., larger test ranges). Additionally, installation realignments could increase the intensity of the use of existing areas. The DoD must fully understand and manage the relationship between readiness and conservation of natural and cultural resources in the land areas. The issue is not *tanks* vs. *environment*; it is *tanks* and *environment*. The DoD Biodiversity Initiative (see Page 48 and facing page text) is a positive example of proactive leadership to address the need and to build community understanding and support for necessary DoD operations on lands that are habitats for threatened and endangered species and contain delicate ecosystems.

Today, conservation requirements are considered *soft* in the DoD planning and budgeting process, in comparison with cleanup and compliance which relate directly to protection of human health. As a result, conservation suffers poor support in resource allocations. This cannot continue. Only if DoD is perceived as a good steward of its lands will it likely attain the needed flexibility for its future operations and training. It is especially critical that stewardship be perceived in a positive way by local stakeholders.

Recommendations

- Develop and implement a proactive program to sustain mission needs, minimize adverse readiness impacts, and conserve resources on the lands DoD manages.
- Develop meaningful metrics for guiding and managing conservation projects.
- Enhance DoD's training program for natural and cultural resource managers as part of the DoD environmental training school system.
- Invest an additional $50M/yr in natural and cultural resource management on DoD lands.

7. **Creating a Stable, $5B/yr Budget for Five Years to Credibly Satisfy DoD Environmental Security Needs.** DoD's environmental requirements are still rising, and will continue to do so through the 1990's. Specifically:

- *Cleanup*: DoD is just now shifting from measurement and analysis to the far more expensive efforts at actual cleanup of active bases.
- *Base Realignments and Closures (BRAC)*: A large, unfunded need remains; yet local stakeholders and regulators desire full implementation of cleanup requirements; additionally, environmental impacts for BRAC-95 are unfunded and only compound the resource problem.
- *Compliance*: New compliance requirements are just now being quantified and some have been found to be inordinately expensive and detrimental to military operations.
- *Pollution Prevention*: There is too little emphasis on pollution prevention throughout DoD.; budget

mechanisms are needed for pollution prevention investments.

- *Conservation*: DoD is just now beginning to understand and quantify its conservation needs such that it can ensure operational flexibility and readiness.
- *Technology*: DoD must accelerate technology demonstration and application in order to achieve its goals within constrained budgets; further, in order to achieve long term cost savings, DoD needs a stable science and technology base focused on defense-unique and very-high-cost environmental demands.

Base Realignments and Closure (BRAC) environmental requirements are of particular concern. In most cases, land cannot be transferred to local entities until cleanup has occurred. Yet BRAC funding is clearly insufficient. The DoD is not now able to meet all of its BRAC-91 environmental funding requirements and the environmental funding for the most recent round of proposed closures (BRAC-95) is not included in current DoD plans and budgets. Even if the total budget can be kept stable, it may not be possible to fund all BRAC work in a timely fashion. Priorities should be established based on the following:

- Significant environmental risks
- Community organization and capability to develop economically-productive uses for the land
- Community and regulator willingness to accept a reasonable cleanup approach

To implement a more efficient and effective environmental security program, budget stability, a long range vision, and metrics to measure program success are all critical. Even a stable, $5B/yr funding level will be insufficient without significant process improvements -- <u>both are required</u>. After FY2000, the required dollars should be less -- as a result of the process improvements being fully implemented.

Recommendations

- Stabilize the DoD environmental security budget at the $5B per year level for five years (FY1996-FY2000). This funding level would include the resource allocation recommendations of this Task Force. Most of the resources will continue to go toward meeting current cleanup and compliance requirements.
- Implement the efficiency and effectiveness recommendations of this Task Force; or even the added funds will be inadequate. In some cases, such implementation will require legislative reform.

<u>In Conclusion</u>. On this, the 25th anniversary of Earth Day, the environment continues to be a major issue for the nation and the DoD, and must continue to be incorporated into the mainstream of the DoD's activities and resource allocations. The Task Force sees the potential for the DoD to dramatically improve its environmental security programs.

The Task Force believes that the DoD must take a leadership role in those environmental security areas that impact its operations and costs. By showing such leadership and working closely with regulators and community stakeholders, the DoD can put itself in a better position to greatly lower its environmental costs and minimize the environmental impacts on its readiness.

In order to implement these recommendations, the Under Secretary of Defense (Acquisition and Technology) should:

- Prepare plans for DoD action on each of the seven opportunities for improvement, with milestones and completion dates
- Periodically (e.g., semi-annually) report progress against these milestones to an independent board.

Report of the Defense Science Board Task Force on Environmental Security

April 22, 1995

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

Office of the Under Secretary of Defense
(Acquisition and Technology)

Scope

- Investigate technology and policy changes that can have a dramatic impact on DoD environmental security:
  - Cleanup (cheaper, faster, smarter)
  - Compliance (to regulatory requirements)
  - Pollution Prevention (in weapon system life cycles and facilities)
  - Conservation (especially regarding military readiness impacts)
- Review and analyze:
  - existing policy and guidance and the effectiveness of implementation
  - current programs and budgets
  - prior studies, audits and analyses
- Consider activities of other agencies and industry
- Recommend strategy and specific plans of action

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- *Dr. Robert Brammer, TASC*
- *Dr. Robert Brown, MIT*
- *Ms. Leslie Carothers, United Technologies Corp.*
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- *Dr. Clyde W. Frank, Deputy Assistant Secretary (Technology Development), Department of Energy*

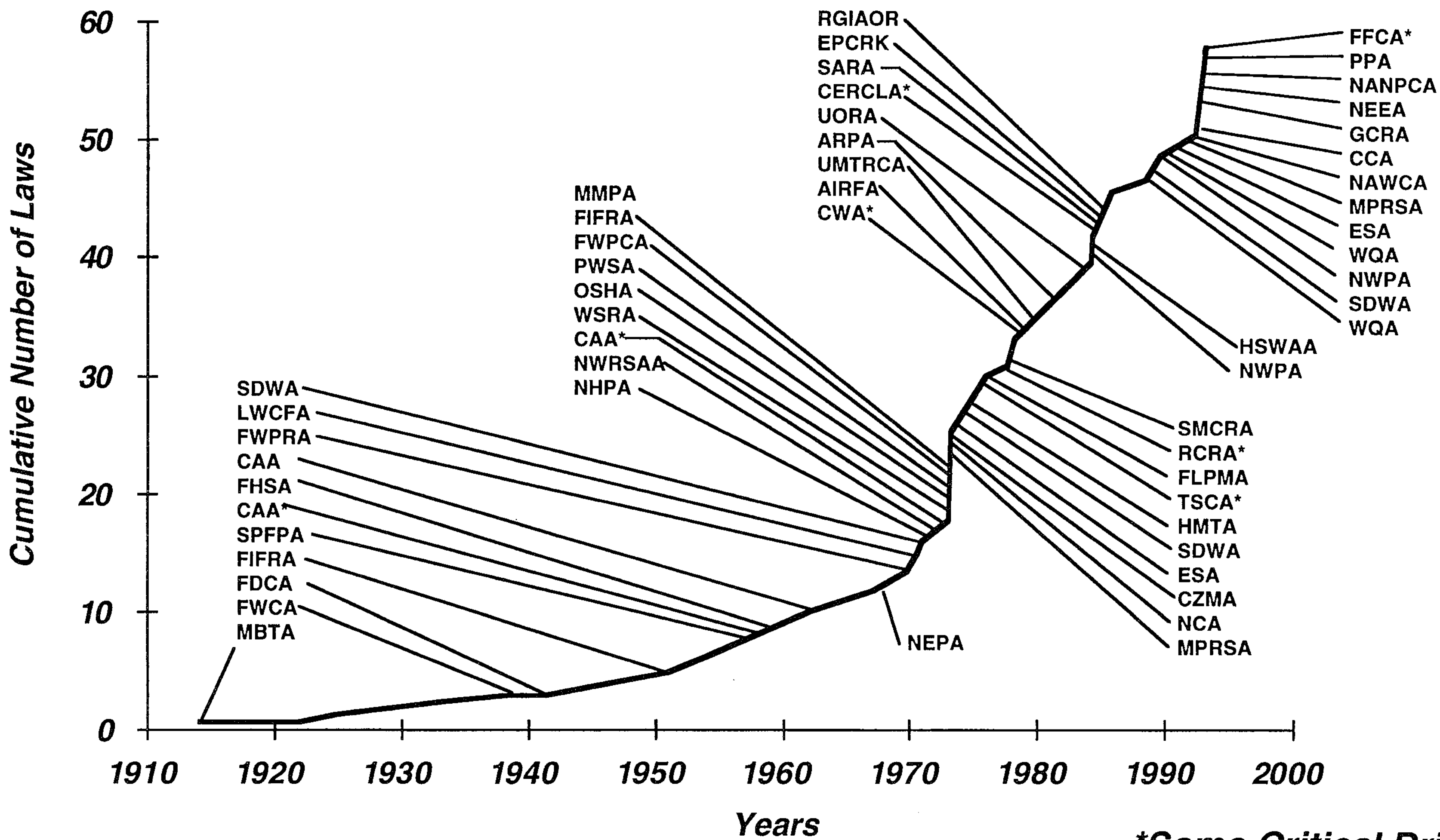
Overview

- *The Task Force believes that:*
  - *As one of the nation's largest environmental managers, DoD cannot avoid the demands of environmental statutes and regulations*
  - *The fundamental requirements of environmental protection are commendable and here to stay*
  - *Recent increase in environmental regulation affecting DoD is cause for concern regarding potential for greater future impacts*
    - » *large and increasing costs for cleanup and compliance against declining environmental security budgets*
    - » *potential (and in some cases actual) degradation in military readiness resulting from environmental requirements*
  - *Given recent trends, environmental security activities are of increasing significance to national defense planning and peacetime military operations*

The Driving Force - Federal Environmental Legislation

This figure lists the wide variety of Federal environmental laws put in place during the twentieth century. The many acronyms listed are defined in Appendix C. The requirement to comply with a growing number of often conflicting regulations and statutes (federal, state and local) within a constrained budget, has been very difficult for DoD. The overall cost to DoD of complying with all of these laws is staggering. As an example of the costs associated with environmental security, the paint changes necessary to comply with Clean Air Act are estimated to cost DoD approximately $1.2B. Due to budget limitations, DoD is forced to make investment decisions from among various competing projects. Satisfactory compliance with existing statutes is becoming more difficult.

The Driving Force - Federal Environmental Legislation



*Some Critical Drivers

Overview

There is a high demand for cleanup of past environmental damages. This has led to very significant levels of DoD investment. The Rocky Mountain Arsenal provides a specific example of the type of cleanup effort facing DoD. Rocky Mountain Arsenal has been DoD's largest cleanup effort as well as being one of the largest in the nation. After being established in 1942, the Arsenal produced chemical munitions and pesticides until the 1970s. Clean-up of this arsenal began in 1978 and, to date, DoD has spent over $500M on the clean-up effort. Considerable clean-up has been accomplished at the arsenal through destruction of over 8 million gallons of fluid from the famous Basin F (out of a total of ten million), plugging of the 12,000 foot deep injection well and 200 farm wells, disposal of 70,000 drums of salt, treatment at the boundary systems, transport of several hundred tons of steel to be melted down prior to resale, and removal of thousands of tons of asbestos. The results of this investment show that levels of contaminants in groundwater have dropped dramatically. However, there is a very significant future investment still required!

Overview (Cont.)

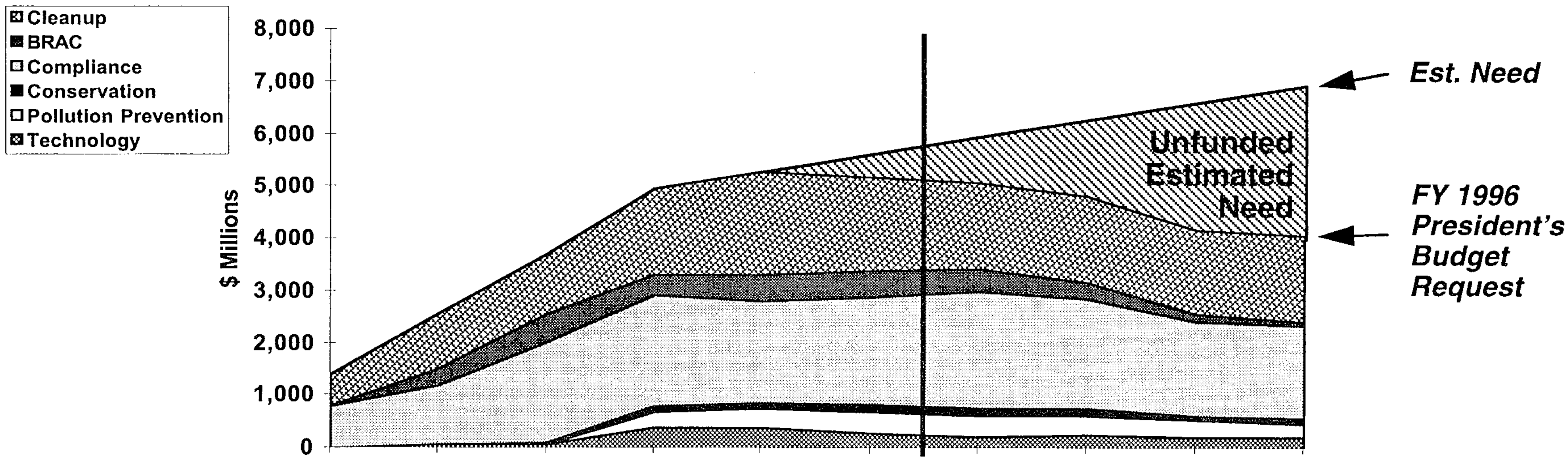
- *DoD has made notable recent progress, but is still reacting to regulatory requirements as they arise*
  - *Today's investment level is marginal for timely response*
  - *In the event of shrinking budgets and with growing demands, the situation will deteriorate*
- *DoD must move away from a largely reactive approach and take an integrated, longer term view*
- *Two areas of great concern are achieving environmental results at reasonable cost and minimizing environmental impacts on readiness*
- *The Task Force recommends a significant conceptual change, requiring a new management approach to DoD's environmental security activities*

Costs

The Budget Dilemma

The future budget dilemma portrayed in this figure is notional in character. The table and lower portion of the curves represent the President's proposed Fiscal Year 1996 budget (and out-year plans) for environmental security programs. The top curve designated as "unfunded estimated needs" does not represent either DoD's or this Task Force's specific statement of the need. Rather, the number is the Task Force's considered estimate of the need, based on the growing demand for resources (see subsequent pages, such as pages 10 and 51).

The Budget Dilemma



	90	91	92	93	94	95	96	97	98	99
Cleanup	601	1,065	1,130	1,639	1,965	1,780	1,630	1,630	1,630	1,630
BRAC		304	540	404	526	518	451	325	149	77
Compliance	790	1,108	1,930	2,118	1,921	2,065	2,241	2,119	1,779	1,766
Conservation		10	25	133	132	144	148	139	99	104
Pollution Prevention				274	338	386	370	345	291	257
Technology		77	70	393	411	290	229	257	232	225
Total	1,391	2,564	3,695	4,961	5,293	5,183	5,069	4,815	4,180	4,059

FY96 proposal budget estimates exclude BRAC-95 and all funding associated with industry costs on weapon systems, which is estimated to be approx. $2B/yr (i.e., 2% of a total annual expenditure of the $100B for R&D, Procurement and Support) -- future funding could be lower, based on actions by Congress and/or the Administration

The Worsening Budget Dilemma

- ***Increasing Requirements for Environmental Dollars***
  - *Shift from "Study" to "Clean Up" will raise costs*
  - *Insufficient funds exist for cleanup of bases on prior closure lists*
  - *BRAC-95 cleanup additions not yet included in budget*
  - *Congressional Budget Office states that: "DoD will probably need additional funds, beyond those in the current budget, plan to continue to meet the program's objectives...legislative relief may be required..." (January 1995)*

- ***Projections of Shrinking Budgets Available to Address Environmental Demands***
  - *By Administration (in outyear budgets)*
  - *By Congress (as considered "non-defense")**

* *For example, the recent congressional recission of $300 million FY95 DoD environmental cleanup dollars*

To Address Growing Demand for Resources

- *More rapid validation and deployment of new commercial technology for DoD use*
- *Investment in early development and deployment of emerging technology -- aimed at defense-unique requirements*
- *A focus on implementation of pollution prevention actions*
- *Comparative-risk-reduction prioritization of investments*
- *Greater efficiency and effectiveness of environmental management (do more with less funding)*
- *Stability of funding (for next five years -- at $5B/yr.)*
- *Adjustments in environmental legislation (e.g. regarding land-use, timing, etc.)--consistent with risk reduction prioritization*

Readiness

Growing Number of Examples of Potential Readiness Impacts

- *Limitations imposed on Air Force use of test and training ranges*
- *Constrained Naval operations from differing oil discharge standards in US waters (harbors, rivers and coastal regions)*
- *Constraints on use of military aircraft and ground support vehicles due to California air quality standards*
- *Reduction of Navy's ability to use sonar devices in tests and exercises because of the potential adverse effect on marine mammals*
- *Limitations on Army armored vehicle maneuvers in training ranges that are habitats of threatened or endangered species (e.g., desert tortoises)*

Potential Readiness Concerns for the Future

- *DoD is one of the largest land owners in the United States (>25 million acres)*
  - *Unique vegetation and many unique species and habitats*
- *With overseas areas increasingly restricted and with longer range weapon needs, the requirement for domestic air, land and water for training, testing and operations is growing*
- *Conservation demands are increasingly restricting DoD's domestic land, air and water activities*
- *A proactive DoD approach to future issues is required today*
- *If perceived as a good steward of the lands, DoD will likely retain greater flexibility for its testing, training and operations*
  - *Especially critical at the local level*

Overall Status: DoD is Moving in the Right Direction

- *Focusing attention on Environmental Security as a significant component of National Security and military Readiness*
- *Developing DoD-wide guidance for Environmental Security*
- *Developing an Investment Strategy for Environmental Science and Technology and a program for new technology transition/ verification*
- *Initiating the development of a risk management methodology for cleanup*
- *Attempting to evolve metrics to provide information for continuous process improvement*

Selected Positive Gains in Cost Reduction and Readiness Enhancements

- *New explosive materials that are reusable/recyclable <u>and</u> have significantly greater energy density and lower production cost*
- *High velocity spray technique for applying coatings that eliminates toxic chromium waste and increases piston lifetime by 3 to 10-fold*
- *Ship propeller guard that protects manatees and also improves propeller efficiency by 30%*
- *Substitution of aqueous parts washers for solvent vapor degreasers, reducing cost and waste while improving quality*
- *High pressure water blasting, using non-toxic detergents, reducing solvent use, waste and cost*

Summary

- *Environmental Security is growing as a DoD issue area*
- *A DoD-wide System for setting priorities is needed (that balances risk reduction potential with costs)*
- *Without change, DoD will Have:*
  - *Unnecessary risk and ineffective use of resources*
  - *Inefficient investment in Environmental Security,*
  - *Use of outdated technology, and*
  - *Increased threats to readiness*
- *Significantly, with restrictive budgets and growing resource needs, the DoD will not be able to satisfy its environmental commitments in a timely fashion*
- *There is clear evidence that better results are achievable*
  - *The DoD must set goals and metrics to measure accomplishment of the goods through the year 2000*
  - *Specific actions must be initiated to achieve these objectives*

Seven Big Opportunities for Improvement

1. A management program of cleanup, compliance, prevention and conservation projects based on comparative risk reduction
2. Increasing focus on, and investment in, pollution prevention
3. Accelerating technology development and deployment
4. Integrating environmental considerations into weapons systems life cycles
5. Assuring efficient and effective implementation through benchmarking and appropriate metrics
6. Developing a proactive focus on natural and cultural resource conservation issues impacting readiness
7. Creating a stable, $5B/yr budget for the next five years to credibly satisfy environmental needs

1. A Management Program of Cleanup, Compliance, Pollution Prevention, and Conservation Projects Based on Comparative Risk Reduction

Issues

- *DoD environmental security funding will not be sufficient to fully satisfy all cleanup and compliance requirements in a timely manner*
  - *President's FY 1996 budget request for defense environmental security is not sufficient to allow DoD to meet its regulatory commitments; the FY1995 recision exacerbates the problem*
- *DoD's current reactive, case-by-case approach often fails to address highest risks first*
- *Under a resource-constrained condition, a management approach based on comparative risk reduction is required to set priorities*
- *To fully implement such an approach, will require close cooperation with regulators and other stakeholders (particularly at the local level)*

Environmental Analytic Tools

- **Risk Assessment**
  - Very traditional methodology
    - » Toxicity
    - » Dose Response
    - » Exposure
    - » Quantification
  - Used for individual decisions, e.g., to ban a pesticide.
- **Comparative Risk Assessment**
  - Comparing risks within categories, e.g., health; and between categories, e.g., health & ecology
  - Only partly quantitative, e.g., cancer risk
  - Requires difficult judgment calls
    - » Comparing premature deaths of elderly vs. neurological damage to children
- **Cost Effectiveness Assessment**
  - Cheapest way of achieving a set objective, e.g., a standard
  - Cheapest way to achieve overall ambient standard
  - Marketable permits are an approach to implement in environmental area
- **Cost Benefit Assessment**
  - Sparsely used in environmental area, but used widely elsewhere
    - » Health benefits (measured by medical costs avoided, productivity of workers, etc.)
    - » Economic benefits, (measured by reduced material damages, crop damage, etc.)
  - Very hard to estimate benefits

Comparative Risk Reduction = Comparative Risk Assessment Plus Cost Analyses

Comparative Risk Reduction/Cost Management

The Task Force recommends that DoD focus analytic resources on estimating the environmentally-related risks at various DoD sites and facilities. Environmentally-related risks include ecological risks, health risks, risks that cultural or natural resources will be damaged or lost (artifacts, habitats and species), risk of regulatory penalties and other risks associated with the environmental impact of DoD operations. Once such risks have been characterized, the Task Force sees the need to estimate how to reduce such risks, by how much and at what cost. Cost of reducing risk includes the degradation of operational military readiness as well as financial costs. Comparative risk reduction analysis includes all such elements.

Another important aspect of the Task Force recommendation is the focus on involving local and state stakeholders. Such stakeholders include local and state regulators, local interest groups and individuals who have a personal or financial interest in the environmental condition being assessed. Such stakeholders must be able to understand the Department's analytic approaches, thus the need for a simple and comprehensible process.

Comparative Risk Reduction / Cost Management

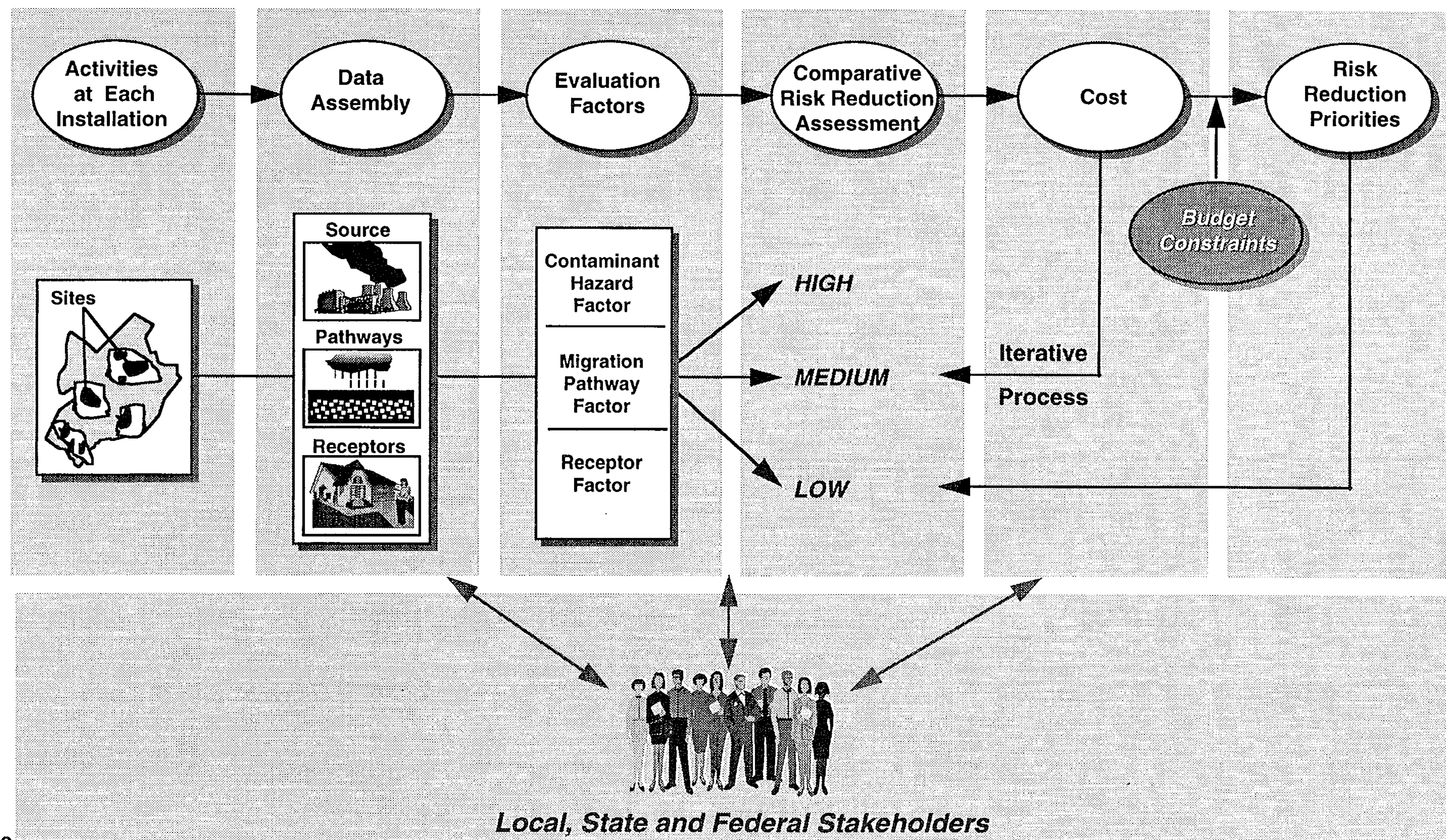
- *Initially rank environmentally-related risks into broad categories*
- *Then consider the costs to potentially reduce the risks*
- *Then perform comparative risk reduction analysis within available budget constraints*
- *Apply comparative risk reduction approach across all DoD environmental security programs*
- *Actively involve stakeholders in the decision process (especially, at the local level)*
- *Keep the process <u>simple and comprehensible</u> to all interested parties and stakeholders*

Example: Optimizing the DoD Investment Based on Comparative Risk Reduction for Cleanup

DoD has many examples of the relationship between level of risk (e.g., land use standard) and cleanup costs. The table below lists some of these examples.

Location	Site Type	Cleanup Costs to Residential Standard ($M)	Cleanup Costs to Alternative Use Standard ($M)	Cost Savings ($M)
Mississippi Army Ammunition Plant	Lagoon Soils	47	2 (industrial)	45
Louisiana Army Ammunition Plant	Groundwater	9	3 (industrial)	6
Sierra Army Depot	Leaching Beds	8	1 (industrial)	7
Joliet Army Ammunition Plant	Operating Unit 1	14	4 (industrial)	10
	Operating Unit 2	8	1 (industrial)	7
	Operating Unit 3	42	21 (recreational)	21
	Operating Unit 5	10	5 (industrial)	5
	Operating Unit 6	5	1 (industrial)	4
Twin Cities Army Ammunition Plant	Various Soils	12	10 (industrial)	2
		9	8 (industrial)	1
		27	15 (industrial)	12
		15	5 (industrial)	10

Example of Comparative - Risk-Reduction/ Cost Management for Cleanup



Example: Optimizing the DoD Investment Based on Comparative -Risk-Reduction for Cleanup

- **Variables to optimize**
  - Risk reduction potential
  - Costs of cleanup
  - Time to cleanup (e.g., bioremediation takes longer)
  - Political factors (e.g., incinerators may not be acceptable)
  - End-use assumptions (e.g., acceptable levels of risk, cleanup standards for intended land use)
- **Comparison of competing approaches. For example, certain sites may be:**
  - Inexpensive to reduce from high to medium risk, but very expensive to reduce from medium to low risk
  - Inexpensive to go from medium to low -- once they are reduced from high.
  - Inexpensive to reduce from high to low but take a longer time than regulatory requirements demand

Barriers to Implementation of Comparative Risk Reduction Management

- *Opposed by:*
  - *Some environmental groups and local interests as an attempt to avoid responsibilities*
  - *Seen by some in DoD as complicating the process*
- *With few exceptions, databases and models for rigorous application do not exist (therefore, initial efforts will be largely qualitative)*
- *DOE experience demonstrates the difficulty and importance of finding meaningful criteria*
- *Must be relatively simple and comprehensible to stakeholders*
- *However, the risk-based approach is becoming more generally acceptable today to a wide variety of interested parties*

1. A Management Program of Cleanup, Compliance, Pollution Prevention, and Conservation Projects Based on Comparative Risk Reduction (Cont.)

Recommendations

- ***Institute a comparative risk reduction approach for budget planning in all environmental areas (cleanup, compliance, pollution prevention and conservation) -- begin during the FY 1997 budgeting process***
  - *Initially, implement a qualitative approach based on management and stakeholder judgments*
  - *Strive for quantitative data wherever available (e.g., in the cleanup area)*
  - *Actively pursue involvement with stakeholders through advisory boards (including federal, state and local regulators)*
  - *Over time, develop credible, understandable quantitative evaluation tools and databases for showing the comparative risks, cost-effectiveness, and times associated with alternative cleanup, compliance, pollution prevention, and conservation efforts*
  - *Exclude technology development and deployment efforts from such prioritization; otherwise they will not get funded*

1. A Management Program of Cleanup, Compliance, Pollution Prevention, and Conservation Projects Based on Comparative Risk Reduction (Cont.)

Recommendations (cont.)

- *Develop an overall implementation plan to reduce most serious risks and to tackle projects with greatest potential for risk reduction, given available resources*
- *Evaluate the critical drivers for risks associated with DoD environmental security. Particularly:*
  - *Land-Use*
  - *Time to achieve compliance or cleanup*
- *Push for consistent national and international standards in areas affecting DoD operations (such as ship discharges) to reduce environmental risks without impeding military operational flexibility*
- *Greatly expand the use of modern modeling and simulation tools and techniques applied to DoD environmental problems*

Example: Modern Modeling and Simulation Tools Applied to Groundwater Contamination Remediation

Goal: To optimize the tradeoff between the variables of acceptable risk and cost in order to establish priorities among remediation design strategies for an Air Force site where groundwater is contaminated with trichloroethylene (TCE).

Starting in 1979, studies were conducted and a data base was established which characterized the TCE plume and subsurface soil conditions at the site. Based on this data and the best available insight and experience of groundwater professionals at the time, a groundwater remediation strategy was formulated using 29 recharge and discharge wells. Pump and treat operations began in 1987. A remediation objective was to retract the plumes and reduce the TCE concentration to five parts per billion, i.e., drinking water safe, within a 20-year treatment period.

Due to the complexity of groundwater systems, groundwater professionals find it difficult to achieve optimal design strategies for groundwater remediation. Using site characterization data, new computer models today can simulate the response of a TCE plume to various remedial designs. Furthermore, using optimal design software, this data can be used to determine an optimal remediation design strategy for a site based on risk, time and cost.

Using the site characterization data base developed between 1979-1986 for the Air Force site, the Task Force used a new groundwater computer model that projected the TCE plume that should have resulted after six years of pump and treat operations using the 29 well system. Compared to a plot of actual characterization data collected in 1993, the simulation resulted in a good representation of the contaminants. The model then was used to project the residual concentration of TCE, and the associated cost, after 20 years of pump and treat using the 29 well configuration. It determined that a residual concentration no less than 100 micrograms/liter of TCE could be achieved (20 times the desired standard) and the cost would be $102 Million.

Using the modern, groundwater computer model in combination with new optimal design software and an iterative process of comparing the residual TCE concentration and cost of candidate well network designs, a least-cost design was developed (see appendix D). This design is capable of achieving the same level of cleanup as the 1987 design generated by the groundwater professionals, but requires only six of the current 29 wells and changes the rate of water recharge and discharge. The least cost solution is $18 Million and represents a savings of $84 Million. If new well locations could be used, the savings would be higher.

Example: Modern Modeling and Simulation Tools Applied to Groundwater Contamination Remediation

Goal

- *Optimize the tradeoff between the variables of risk and cleanup cost*
- *Establish cleanup priorities where groundwater is contaminated with trichloroethylene (TCE)*

Background on Specific Analysis

- *Objective -- retract the plumes and reduce the TCE concentration to five parts per billion, i.e., drinking water safe, within a 20-year treatment period (1987 through 2007)*
  - *Data base characterized the TCE plume and subsurface soil conditions at the site*
  - *Groundwater remediation strategy selected used 29 recharge and discharge wells*
  - *Pump and treat operations began in 1987*
- *Task Force employed a modern, groundwater computer model (simulation) in combination with new optimal design software*
  - *Least cost solution requires only six of the 29 wells; changes the rate of water recharge and discharge*
  - *Least cost solution costs $18 Million, representing savings of $84 Million*
  - *If new well locations used, savings would be higher*

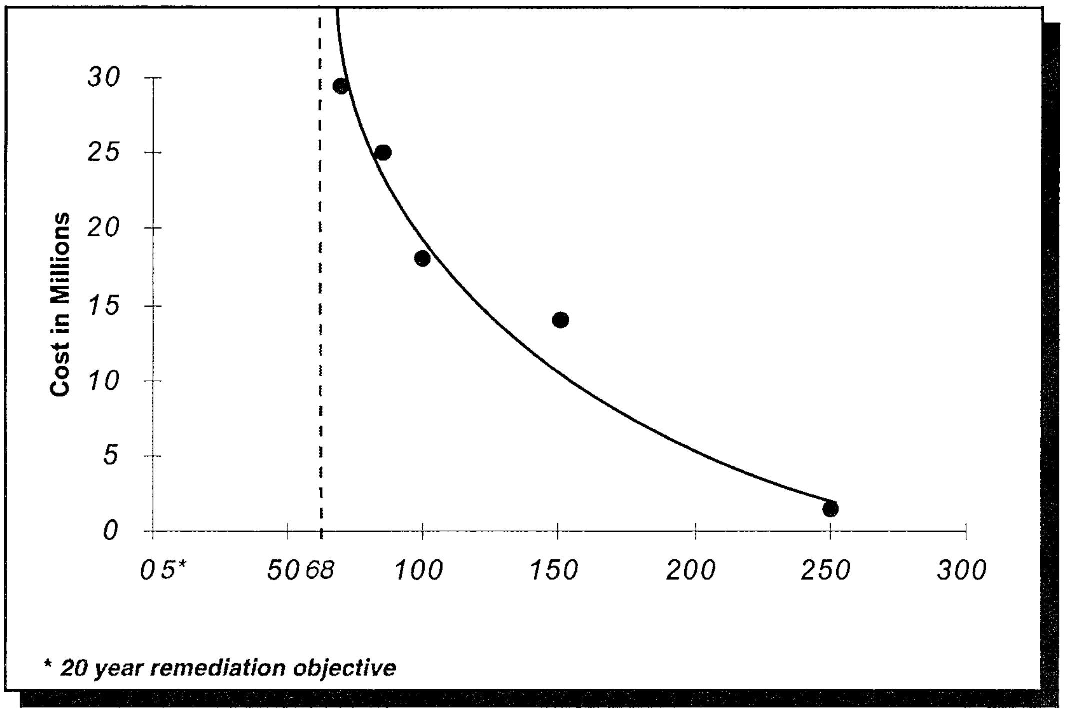
Example: Modern Modeling and Simulation Tools Applied to Groundwater Contamination Remediation (Cont.)

The model demonstrated that the acceptable level of risk, e.g., residual concentration of TCE, has a significant impact on cost. For example, keeping "time to comply" constant at 20 years (see figure on facing viewgraph), it was not possible to find a design strategy that would reduce the concentration of TCE below 68 parts per billion <u>at any cost</u>. The model clearly demonstrated that the Air Force site's 20 year remediation objective of 5 parts per billion is not achievable.

Solvents, such as TCE, are among some of the most frequently reported contaminant groups at DoD sites, and represent a significant portion of cleanup costs. A quantitative relationship between cost and the acceptable level of residual solvent concentration can be developed using a modern, groundwater cleanup computer model of these DoD sites, along with non-linear optimization. Once this information is developed, decisions can be made regarding an appropriate level of cleanup at a site and the time permitted for cleanup. By comparing similar analyses completed for multiple contaminated sites, priorities can be set among sites and available resources can be allocated more effectively and efficiently.

Example: Modern Modeling and Simulation Tools Applied to Groundwater Contamination Remediation

- ***Model demonstrated that the acceptable level of risk has a significant impact on cost***
  - *Keeping "time to comply" constant at 20 years, the model could not find a 20 year least cost solution that would reduce the concentration of TCE below 68 parts per billion at any cost (see figure below)*
  - *This demonstrated that the 20 year remediation objective of 5 parts per billion (the drinking water standard), set in 1987 for the Air Force site, is not achievable*



Cost to Meet Remediation Objective in 20 Years

Increasing Focus on Pollution Prevention

Pollution prevention has had lower priority within DoD due to the critical need for clean-up and compliance. Compounding this problem is the fact that life cycle environmental costs and the real payoff from prevention have not been fully quantified. Pollution prevention inherently has a longer term payoff that is harder to measure. In some cases, the benefits of pollution prevention have also had a positive impact on weapons performance and readiness. For example, DoD has developed new energetic materials designed for recycle and reuse that also have increased energy density and lower production cost. Clearly, there have been many examples of the military payoff and cost avoidance from pollution prevention. The table below lists certain of these.

Over the past two years, the Department has completed a number of promising pollution prevention programs. It has worked closely with the aerospace industry to adopt a national aerospace standard for aerospace hazardous materials. The DoD has established the National Defense Center for Environmental Excellence (NDCEE). Some commercial firms have demonstrated positive return on investment in pollution prevention. Successful companies are now making significant investments in pollution prevention. In fact, industry has found that effective pollution prevention programs involve a large number of diverse initiatives (essentially, a "bottoms-up" program), led at the "factory-floor" level.

Pollution Prevention Initiative	Total Investment	Pollution & Waste Reduction (lbs/yr)	Other Benefits	Cost Avoidance ($/yr)	Payback Period (yr)
Ion Vapor Deposition (IVD) Aluminum	$900,000	13,000	Replaces cadmium in 80% of applications	$140,000	6.4
Two Buss Bar	$130,000	500		$205,000	0.6
Testing to Minimize Reactive Wastes	$204,000	80,000		$200,000	1.0
HVOF	$50,000	1,000		$193,000	0.3
Non-Solvent Parts Washer	$249,200	99,200	No ozone depleting substances or hazardous air emissions Reduced water consumption by 87%	$453,000	0.5
Waste Metal Shredder	$80,000	2000 cu yds		$1,092,000	Immediate
Spray Wash Cabinets	$287,000	30,000	Reduce 100,000 lb/yr of 1,1,1-trichloroethane emissions		
Metal Treating	$900,000	75,900		$275,000	3.3
Paint Stripping	$1,310,000	124,000		$264,000	5.0
Reclamation of Chromium from Plating Baths	$80,000		94% reduction of chrome and rinse water waste	$35,694	2.3
Environmental Control Center	$409,000	72,000	Recycling of HazMat increased from 45 to 144 tons Stock of HazMat reduced by 75%	2,270,000	0.2

2. Increasing Focus on Pollution Prevention

Definition

- Pollution prevention is the reduction or elimination of pollution generation through substitution of inputs, process changes, and better housekeeping

Issues

- Task Force finds too little emphasis on pollution prevention
  - Pollution prevention often demonstrates significant returns on investment
  - In spite of this, pollution prevention projects are underfunded during budget tradeoffs
  - Today, there are insufficient incentives for cost reducing, longer term investments
- Over the past two years, the Department has completed a number of promising pollution prevention programs. For example:
  - Worked closely with the aerospace industry to adopt a national aerospace standard for aerospace hazardous materials
  - Air Force/industry propulsion consortium for long range environmental technology R&D
  - Joint initiative in acquisition pollution prevention to minimize waste generation
  - Implemented a significant number of specific pollution prevention initiatives
- Many commercial firms have demonstrated positive return on investment through pollution prevention
  - Effective pollution prevention programs involve a large number of diverse initiatives
  - Successful companies are investing in pollution prevention

2. Increasing Focus on Pollution Prevention

The Task Force recommends that DoD develop new incentives for pollution prevention as well as new budget mechanisms for funding pollution prevention initiatives, as outlined on this viewgraph. Local commanders should be allowed greater flexibility in the use of non-appropriated funds (e.g., money from recycling) and in the defense business operating funds (DBOF) as an incentive to invest in pollution prevention at the local level

The metrics proposed for DoD use in judging progress toward pollution prevention goals must be targeted toward the program managers and facility commanders who will actually be held accountable for meeting them. Without targeting the metrics in this way, the people who will be held accountable will not be able to relate to the DoD goals. The goals established by the Department must be demanding (e.g., the current DoD-wide goal of reducing waste by 50% may not be demanding enough; perhaps 90% may be more appropriate). Such goals, however, should not lead to investments with low return on investment.

2. Increasing Focus on Pollution Prevention

Recommendations

- **To establish incentives and new budget mechanisms for increased investment in pollution prevention:**
  - Strengthen the commitment of senior leadership in their decision making, to the value added from preventing pollution
  - Incorporate pollution prevention criteria into RDT&E, production, operations, maintenance/support and disposal program investment policies in the PPBS process, such as the Defense Planning Guidance and the Program Objective Memorandum Preparation Instructions
  - Significantly increase RDT&E, production, and maintenance program investments in pollution prevention (e.g., "life cycle design for the environment")-- phase in such increases over a six year period
  - Immediately allocate an additional $100M/yr for pollution prevention initiatives to appropriate military Service programs
  - Work with the defense industry to facilitate (and incentivize) investments in pollution prevention
  - Encourage pollution prevention as a mechanism for achieving compliance
  - Allow local commands to use net savings from pollution prevention investments for other initiatives
  - Use non-appropriated funds (e.g., money from recycling) and defense business operational funds to incentivize pollution prevention
- **Develop and use result onsite metrics and benchmarking to monitor progress and manage pollution prevention programs**
  - Establish demanding goals , relate goals to investments, set levels for individual performers, and monitor progress

3. Accelerating Technology Development and Deployment

Issues

- *Many existing environmental technologies offer significant risk and/or cost reduction potentials that are not being realized (due to institutional inertia and regulatory barriers)*
- *Many DoD environmental problems are identical to those of public (e.g., DOE) and private sectors and are amenable to treatment by technologies developed outside DoD*
  - *However, some DoD-unique environmental problems require development of new technologies by DoD*
- *There is a need to reduce the timeframe for environmental technology demonstration, verification and application*
  - *Often, there is not a sufficient cadre of trained technical personnel nor underlying infrastructure to select and utilize a new, more effective technology*
- *The biggest bottleneck is <u>deployment</u> of new environmental technology (e.g. technology demonstration and verification) via accepted performance and cost protocols*
- *Technology demonstrations can be an important part of DoD's process for achieving more rapid verification and deployment of the most promising technologies*
  - *For cleanup, multiple demonstrations are needed to span the variability of applications*
  - *DoD should build on current DoD and national environmental technology demonstration and verification programs*
  - *On the weapons side, there have been very few examples of early application of new technologies as part of "design for the environment"*
- *There is a growing concern that, with shrinking environmental security budgets, sufficient environmental science and technology investments will not be made to dramatically reduce future costs*

Industry and Defense Have Many Common Environmental Problems

For Example, Some of the Most Frequently Reported Contaminant Groups at DoD Cleanup Sites Are Identical to Commercial Sites

Army (of 1,114 Sites)	%	Navy (of 995 Sites)	%	Air Force (of 1,834 Sites)	%
Heavy Metals	25	POLs	38	POL-Petroleum/Oil/ Lubricants	43
POLs	15	Solvents	22	Solvents	15
Pesticides	7	Paints	12	Heavy Metals	14
Solvents	7	Heavy Metals	11	Petroleum/Oil/Lubricant Sludge	5
Chlorinated Solvents	7	PCBs	9	Acid	4
Inert Material	6	Pesticides	7	Chlorinated Solvents	4
POL Sludge	6	Acids	6	Pesticides	3
Scrap Metal	4	POL Sludge	4	Scrap Metal	2
		Refuse	4	Inert Materials	1
		Industrial Wastewater	4		

Therefore, DoD Must Capitalize on Developed Commercial Environmental R&D

Some DoD-Unique Difficult and/or High Cost Unresolved Environmental Problems

- *Open-air burning of retired munitions*
- *Demilitarization of stockpile of chemical weapons*
- *Recharging lithium boilers within propulsion system of MK 50 torpedo*
- *Biodegradable plastics (for Army food packaging in field)*
- *Compacting shipboard wastes*
- *Detection, characterization, extraction and disposal of unexploded ordnance on land and under water*
- *Remediation of soil, surface water and ground water contaminated by explosives and energetics*
- *Treatment and control of liquid and gaseous waste streams from the production of energetics and explosives*
- *Remediation of white phosphorous contaminated soils and sediments*
- *Elimination of shipboard discharges*
- *Remediation of military-unique compounds in soil, surface water and ground water*

Technology Investment Areas

- ***Investment is required in two broad areas to address DoD environmental needs:***
  - ***Development and field demonstration of promising new technologies***
  - ***Rapid full-scale verification and application of demonstrated technologies***
- ***Some examples of technologies in each area are shown on the next two slides***

Some Examples of Technologies for Development/Field Demonstration

Clean-Up

- *Natural and accelerated in-situ bioremediation of groundwater contaminated by solvents or chemicals from explosives manufacturing*
- *Co-metabolic bioventing for remediation of soils contaminated by halogenated compounds*
- *Advanced sensor systems for characterization of contaminated sites and for identification of unexploded ordnance and non-aqueous phase liquids*

Compliance

- *Membrane technologies (ultrafiltration and reverse osmosis) for decontamination of aqueous waste streams*
- *Biofiltration and sorption/catalysis systems for decontamination of air streams*
- *Advanced thermal and supercritical fluids technologies for treatment of heavily contaminated slurries, sludges and solids*

Pollution Prevention

- *Recyclable and reusable energetic materials*
- *Microlayer coatings allowing for easy cleaning*

Conservation

- *Advanced ecosystem sensing and mapping techniques*

Some Examples of Technologies for Accelerated Application

Clean -Up

ADVANCED OXIDATION PROCESSES FOR OFF-GASES AND AQUEOUS STREAMS. This process is applicable to the treatment of organic compounds (such as chlorinated hydrocarbons, fuels and solvents) in groundwater and other water. The technology uses ultraviolet (UV) light, ozone and hydrogen peroxide, depending upon the contaminant and media, to destroy the contaminant..

IN-SITU BIOVENTING FOR BETX CONTAMINATED SOILS. This process can be applied to fuels and biodegradable organics. It can be applied to the clean-up of unsaturated soils contaminated with petroleum hydrocarbons. This technology provides oxygen to common strains of soil bacteria which are capable of degrading hydrocarbons. Through this process the cost of recovery and treatment of off gases from the venting process is significantly reduced and may be eliminated entirely.

CORE PENETROMETER FOR SITE CHARACTERIZATION. The SCAPS consists of an instrumented penetrometer and on-board analysis system. It is used to rapidly characterize the extent and character of a subsurface contaminant. While not entirely eliminating the need for monitoring wells, the SCAPS greatly reduces the total number of wells and provides for optimum placement of those wells. The SCAPS has been implemented with its initial suite of sensors. The technologies will permit the SCAPS to detect explosives, heavy metals, specific solvents and radioisotopes.

Compliance

NON-POLLUTING/BIODEGRADABLE ANTIFOULING MARINE COATINGS. Current marine antifouling coatings inhibit unwanted marine growth by leaching of toxic substances such as copper into the marine environment. This new technology is based on two basic methodologies. The first is biofoulant "easy-release" technology. The second methodology incorporates biodegradable biocide coatings and natural antifoulants.

TREATMENT OF NITRATED ORGANICS IN MUNITIONS WASTEWATER. This technology is comprised of the anaerobic treatment of dinitrotoluene (DNT) in a fluidized bed reactor followed by aerobic treatment in an activated sludge. This process is designed to treat the wastewater from explosives manufacturing processes and will eliminate large volumes of toxic waste.

Pollution Prevention

ELECTROLESS NICKEL PLATING BATH REJUVENATION. This technology permits the rejuvenation and reuse of nickel electroplating baths. This process eliminates the need to dispose of spent plating bath solutions. Instead, the only waste product from the process is a solid which is removed from the solution and sold for other purposes

CONTINUOUS AQUEOUS CLEANING TO ELIMINATE OZONE DEPLETING CHEMICALS. This process is designed to use an aqueous cleaning system for degreasing metal parts prior to the application of coatings. Currently, trichloroethane, which is an ozone depleting chemical, has been used as a vapor degreaser. The technology has been shown to work in batch processing and is now being developed for continuous processes. It will totally eliminate the use of trichloroethane in the degreasing process.

Conservation

ADVANCED SOIL LOSS AND SEDIMENTATION MODELING. This advanced numerical model is designed to permit the prediction of the quantity and rate of soil loss as a result of ground disturbance due to training exercises or construction. The model integrates both existing databases and land cover information as the basis for the predictions.

LAND CARRYING CAPACITY MODEL. Much of military training activities disturb the soil, vegetation and wildlife of military training ranges. This numerical model has been developed to predict what level of training activity and during which seasons may be supported before unacceptable levels of damage occur. The model permits long term planning of training as well as budgeting of repair costs.

Some Examples of Technologies for Accelerated Application

Clean-Up

- *Advanced oxidation processes for off-gases and aqueous streams*
- *In-situ bioventing for BETX contaminated soils*
- *Core penetrometer analysis system for site characterization*
- *Modeling and simulation techniques*

Compliance

- *Non-polluting/biodegradable antifouling marine coatings*
- *Treatment of nitrated organics in munitions wastewater*

Pollution Prevention

- *Electroless nickel plating bath rejuvenation*
- *Continuous aqueous cleaning to eliminate ozone depleting chemicals*

Conservation

- *Advanced soil loss and sedimentation modeling*
- *Land carrying capacity modeling of ecosystem from military maneuvers*

Impediments to Implementing New Technologies

The Task Force heard numerous examples of how the procurement practices of the Department hindered the incorporation of new technology into DoD environmental operations. For example, the Army had a set of procurements where the requests for proposal (RFPs) required cost estimates for the labor hours and capital equipment associated with the traditional approach to finding unexploded ordnance. New sensor approaches that used capital equipment and labor differently were precluded from competition by the structure of the RFPs.

Impediments to Implementing New Technologies

- ***Barriers to application of innovation***
  - *<u>Regulatory problems</u> (e.g., permit requirements and inertia)*
  - *Advanced technology demonstration and validation*
  - *Economics (up front costs)*
  - *Information availability*
  - *Organizational structure and incentives (lack thereof)*
  - *Legal problems (liability)*
  - *Procurement practices (built around older technologies - vs performance needs)*
- ***Incentives are required for encouraging use of innovative technologies***
  - *Acquisition strategy encouraging up front investment of resources*
  - *Means for management and dissemination of verified technologies*
  - *Procurement practices that encourage application of advanced technologies (vs. current practices that discourage it)*

Regulatory and Liability Issues

- ***Reward/punishment incentives in the environmental community typically are risk averse***
  - *Site cleanup managers typically not rewarded for use of a new technology at their site as long as they know that a permitted technology (albeit more costly, less effective) can do the job*
- ***Concerns over performance liability are deterring the use of cleanup sites for new technology demonstration/verification efforts***
  - *DoD and industry cleanup managers are increasingly being held liable for compliance*
- ***Site managers are very reluctant to propose new (lower cost, more effective) technologies since regulatory processes for verification/certification are ad hoc and often uncertain***
  - *Lack of effective approval coordination across states (e.g., regarding test protocols and data acceptability)*

3. Accelerating Technology Development and Deployment (Cont.)

Recommendations

- Devote an additional $150M/yr for accelerated environmental technology demonstration and verification:
  - Support current DoD and national environmental technology demonstration programs
  - Establish an additional fifty to one hundred cleanup sites focused on accelerating the transition of promising environmental technologies into practice
  - Allocate the additional $150 million to the Services - through a Services-managed Joint Program Office - as an incentive for cleanup/demonstration/validation
- A clear assignment of responsibility (such as a joint service program office) should establish protocols, standardize reporting and disseminate results
- Open DoD's sites for technology demonstration and verification of technologies
  - Assure regulatory participation
- Focus resources on demonstrating and validating commercial industry cleanup technology to the maximum extent possible

3. Accelerating Technology Development and Deployment (Cont.)

Recommendations

- *Encourage effective approval coordination among the states for technologies demonstrated under this program*
- *Implement a DoD approach for accepting liability for new technology demonstrations and applications similar to that of DOE; explore need for new liability legislation*
- *Develop a set of incentives (e.g., extra resources, merit bonuses, etc.) for government site directors to utilize new technologies*
- *Expand on existing cooperation among agencies and departments, and with industry, to seek maximum leverage for DoD investments*
- *Urge EPA to develop measures to encourage/empower site managers to approve the use of innovative technologies when appropriate (senior managers in both agencies must be involved)*

3. Accelerating Technology Development and Deployment (Cont.)

Recommendations (Cont.)

- *Maintain the environmental S&T budget at current levels, as a minimum*
  - *Proof of principle and field demonstration efforts are critical element of DoD investments*
- *Prioritize and focus DoD technology investments on high potential environmental technologies that target high risk or high cost problems experienced by the DoD*
  - *Either defense-unique or high cost problems where insufficient commercial effort is taking place*
- *Develop procurement incentives that encourage the early deployment of promising technologies (e.g., procure performance of a function or job rather than the current procurement practice of buying environmental services based on labor hours and rates)*
  - *Pursue management initiatives*
    - » *Clarifying policies and procedures*
    - » *Partnering with regulators and prime contractors*
    - » *Challenging unnecessary or duplicative requirements*
    - » *Training and education*
- *Reevaluate the roles of various participants in DoD environmental technology programs (DoD and national laboratories, industry and academia) to determine whether the resources are being allocated to the most effective performers*
  - *This needs independent review of all performers to ensure that only the best performers are being funded*

4. Integrating Environmental Considerations into Weapon System Life Cycle (R&D to Disposal)

Issues

- *80% of environmental costs (hazardous waste) relate to weapon systems' life cycle costs, including those at military bases (per DoD Inspector General)*
- *Must identify and integrate environmental issues (including pollution prevention) into all aspects of life cycle for systems and components (R&D to disposal)*
  - *Requirements and goals are an element of all decisions*
  - *Meet operational requirements as well as environmental needs within limitations of cost, performance, and schedule.*
  - *Commercial experience has demonstrated that "front end" design for a system's life cycle pays*
  - *Due to the size of its operations, DoD life cycle cost analysis and design for the environment efforts could have a very significant positive impact*
- *Acquisition practices of the Department should adopt appropriate commercial best environmental practices*
  - *This should be a subset of DoD's "acquisition reform" initiative*

Design for Environment

- ***Process in which a product's <u>environmentally preferable attributes</u> (e.g., maintainability, disassembly, recyclability, refurbishability, reusability) <u>are treated as design objectives instead of constraints</u>.***
- ***Three important steps are:***
  - ***Understand the product's environmental impacts, including hazardous materials used/generated, regulation/compliance issues, energy consumption both in manufacture and product use, and disposal concerns.***
  - ***Communicate these findings, together with guidelines, to product designers and manufacturing engineers.***
  - ***Incorporate lessons learned into new and existing product designs (capture lessons from current efforts, e.g. F-22 and V-22).***
- ***<u>Several useful questions to ask:</u>***
  - ***What substitutes for toxic constituents are available?***
  - ***What are the waste streams from the manufacturing processes?***
  - ***What are the environmental impacts of the component materials?***
  - ***How does the design affect recyclability?***
  - ***How is the product actually used by consumers?***
  - ***What happens when the product is disposed of?***
  - ***How is the product managed after disposal?***

4. Integrating Environmental Considerations into Weapon System Life Cycle (R&D to Disposal)

Recommendations

- Integrate pollution prevention into the acquisition life cycle decision process through procedural changes (for new systems, modifications and existing systems; including maintenance and provisioning)
  - Require environmental expertise on integrated product-process teams
  - Establish environmental goals to educate acquisition workforce in environmental considerations
  - Ensure that needed investments are funded
  - Pursue management initiatives
    - Acquisition Policies and Procedures (DODI 5000.2, Defense Acquisition Management Policies and Procedures; IS-632)
    - DAB review process
    - Contract management
    - Life Cycle Costing
    - Review and revise standardized documents
      - Execute the requirements of Executive Order 12856 and 12873
    - Prioritize problems/processes that need to be addressed

4. Integrating Environmental Considerations into Weapon System Life Cycle (R&D to Disposal)

Recommendations

- *Strengthen acquisition and support processes to promote cost-effective environmental practices*
  - *Make environmental considerations a normal part of DoD's life cycle process*
  - *Pursue personnel training and assignment policies that provide environmentally knowledgeable personnel*
  - *Investigate changes to DBOF and other capitalization sources to provide incentives to fund pollution prevention initiatives*
- *Develop and advocate streamlined federal environmental review processes for weapon systems*
  - *Otherwise, as weapons acquisition processes are streamlined, the environmental review process will hinder the deployment schedule*
- *Intensify DoD efforts toward achieving uniform national and international environmental standards in areas affecting many DoD operations*
- *Develop credible life cycle costing (LCC) tools and databases that:*
  - *Focus on rapid development of usable models*
  - *Incorporate predicted environmental costs, risks and performance*
  - *Achieve better ways for accounting for the cost savings associated with pollution prevention*
  - *Pursue management initiatives*

5. Assuring Efficient and Effective Implementation Through Benchmarking and Appropriate Metrics

Issues

- ***Little quantitative data available to compare DoD implementation with other Agencies (e.g., EPA, DOE) or, particularly, with commercial best practices.***
- ***In each area of environmental security, goals need to be established and implementation results measured over time***
  - *Some commercial environmental metrics can be used as a starting point*
  - *Some DoD and DOE environmental metrics can also be utilized*
- ***Congress needs to be assured that environmental security appropriations are being spent efficiently and effectively***

5. Assuring Efficient and Effective Implementation Through Benchmarking and Appropriate Metrics

Recommendations

- *Initiate a benchmarking effort to compare DoD implementation with that of EPA, DOE, commercial industry and foreign practices*
  - *Pick specific non-DoD-unique environmental cleanup sites to start such an effort (e.g., hazardous waste sites)*
  - *Relate metrics to managers' ability to achieve them*
  - *Analyze the differences between best practices and current practices*
- *Define a continuing, DoD-wide process for:*
  - *Benchmarking*
  - *Defining metrics*
  - *Setting goals*
  - *Measuring progress toward goals and rewarding managers*

6. Developing a DoD Proactive Focus on Natural and Cultural Resource Conservation Affecting Readiness

The Task Force was briefed on the DoD Biodiversity Initiative. Under this initiative, the Nature Conservancy has been engaged by the Air Force to survey ecosystems at various bases around the country and recommend how DoD operations can be conducted such that important natural resources at the bases are preserved and ecosystems maintained. This balancing of environmental concerns and those of operational military readiness was held as a good example of how DoD can become proactive in this part of its environmental program.

6. Developing a DoD Proactive Focus on Natural and Cultural Resource Conservation Affecting Readiness

Issues

- *Readiness requirements include large areas of land, airspace, harbors and coastal areas; DoD manages >25M acres containing significant natural and cultural resources*
- *Force modernization is increasing the requirement for domestic air, land and water training, testing and operations (e.g., larger test ranges)*
- *Installation realignment could increase the intensity of use of existing areas*
- *DoD must understand and manage the relationship between readiness and conservation of natural and cultural resources in the land areas*
  - *The DoD Biodiversity Initiative is a positive example of proactive leadership to address the need and to build community understanding and support for necessary DoD operations on lands that are habitats for threatened and endangered species and contain delicate ecosystems*
- *Conservation requirements are considered "soft" in the PPBS process in comparison with cleanup and compliance which relate directly to protection of human health*
  - *Conservation suffers poor support in resource allocations*

A Key Point

- ***Inadequate funding of conservation requirements cannot continue. Only if DoD is perceived as a good steward of the lands, will it likely attain the needed flexibility for its future operations and training***
  - ***It is especially critical that stewardship be perceived in a positive way by local stakeholders***

6. Developing a DoD Proactive Focus on Natural and Cultural Resource Conservation Affecting Readiness

The following list is hypothetical examples of actions to be taken under a proactive focus on natural and cultural resource conservation:

- Positioning targets to avoid Red-Cockaded Woodpeckers at four ranges in the southeastern US
- Fencing Desert Tortoise habitat at Nellis Range, Nevada, to prevent intrusion by people
- Curtailing Delta launches at Vandenberg AFB, California, during Least Tern nesting season
- Modifying flying routes and altitude near Peregrine Falcon nests in Alaska
- Adjusting lights on the launch pads at Cape Canaveral, Florida, to protect sea turtle nests and newly hatched turtles

6. Developing a DoD Proactive Focus on Natural and Cultural Resource Conservation Affecting Readiness

Recommendations

- ***Develop and implement a proactive program to sustain mission needs, minimize adverse readiness impacts, and conserve resources on the lands DoD manages***
  - *Work with local conservation groups, state agencies and EPA to develop cost-effective programs for characterizing ecosystems, protecting such ecosystems and promoting wildlife programs*
  - *Consider ecosystem impacts on weapons' acquisition plans, force needs, and operational needs*
  - *Become a leader in ecosystem and wildlife protection in areas that can directly affect DoD readiness*
  - *Utilize a comparative-risk-reduction/cost management approach for budget prioritization*
- ***Develop meaningful metrics for guiding and managing conservation projects***
  - *Changes to operational constraints*
  - *Changes to environmental resources*
  - *Cost-effectiveness*
  - *These will be adjusted to individual missions (e.g., tank training will generate a different set of metrics than aircraft testing).*

6. Developing a DoD Proactive Focus on Natural and Cultural Resource Conservation Affecting Readiness

Recommendations (Cont.)

- ***Enhance DoD's training program for natural and cultural resource managers***
  - *Many managers understand technical aspects of their jobs but do not understand how to get money to execute them*
  - *Managers need PPBS training in order to secure adequate support*
- ***Continue/expand natural and cultural resource manager training as part of DoD environmental training school system***
  - *Develop environmental training for installation commanders*
- ***Invest an additional $50M/yr in natural and cultural resource management on DoD lands***
  - *Define a consistent "systems approach" for conservation*
  - *Develop budget policy for conservation based upon comparative risk reduction levels*

7. Creating a Stable, $5B/yr Budget to Credibly Satisfy DoD Environmental Security Needs

<u>Regulatory Relief</u>: If DoD is going to meet this nation's expectations of protecting public health and the most sensitive natural resources given forecasted reductions in the Defense Environmental Restoration Account (DERA), it must have relief from Executive Order 12088, which requires the DoD to request full funding each year for all legal requirements.

<u>Impact of Funding Instability</u>: The Task Force received indication that the recent FY 1995 recision with regard to DERA will require the Department to renegotiate written agreements. For example, the Navy indicates that 49 percent (33 out of 67) of the projects that will be affected by this recision have written agreements that will need to be amended. For the Navy, these projects represent 67 percent ($44.79 million out of $66.68 million) of the rescinded funds. This renegotiation process will span the nation and its territories: Arizona, Arkansas, California, Guam, Hawaii, Maryland, Mississippi, New Jersey, North Carolina, Pennsylvania, Puerto Rico, Rhode Island, South Carolina, Virginia, Washington and West Virginia,

7. Creating a Stable, $5B/yr Budget for Five Years to Credibly Satisfy DoD Environmental Security Needs

Issues

- **DoD's environmental requirements are increasing, and the costs to satisfy these requirements will continue to rise through the 1990's. Specifically:**
  - *Cleanup: DoD is just now shifting from measurement and analysis to the far more expensive efforts at actual cleanup of active bases.*
  - *BRAC: A large, unfunded need remains; yet local stakeholders and regulators desire full implementation of requirements; additionally, environment impacts for BRAC -95 are unfunded and only compounds the resource problem.*
  - *Compliance: New compliance requirements are just now being quantified and some have been found to be inordinately expensive and detrimental to military operations.*
  - *Pollution Prevention: There is too little emphasis on pollution prevention throughout DoD; budget mechanisms are needed for pollution prevention investments.*
  - *Conservation: DoD is just now beginning to understand and quantify its conservation needs such that it can ensure operational flexibility and readiness.*
  - *Technology: DoD must accelerate technology demonstration and application in order to achieve its goals within constrained budgets; further, in order to achieve long term cost savings, DoD needs a stable S&T base focused on defense-unique and very-high - cost environmental demands.*

BRAC

Perhaps BRAC funding should be removed totally from the DoD budget and funded as a separate national responsibility.

Issues

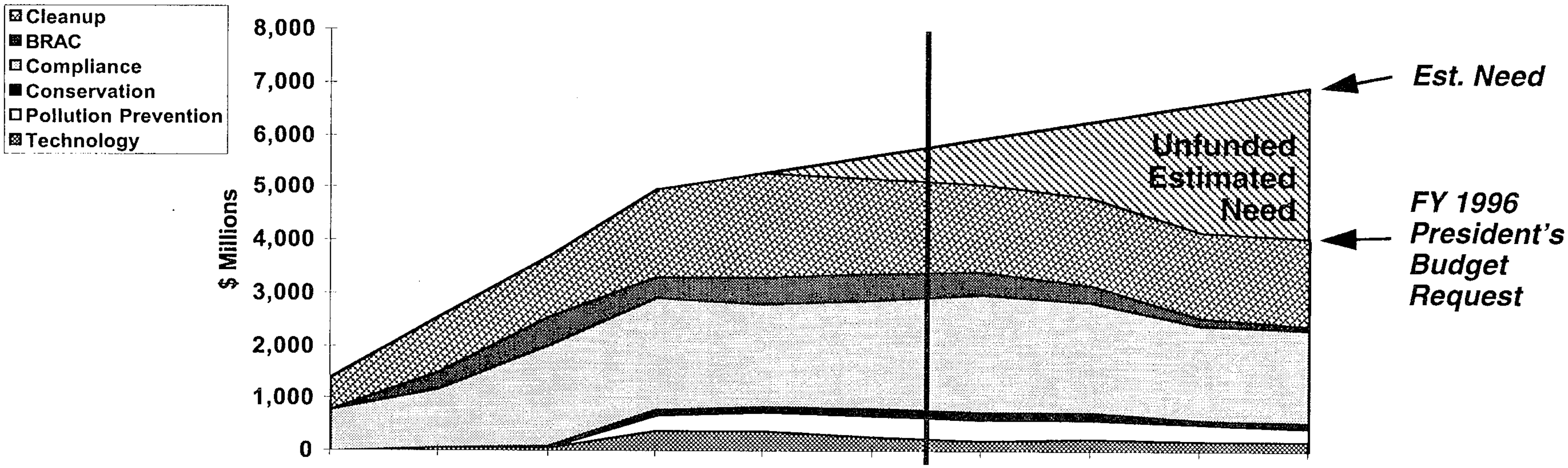
- *BRAC funding is currently insufficient*
  - *Not even able to fund BRAC 91 requirements*
  - *BRAC 95 not included in plans and budgets*
- *Priorities must be established based on the following:*
  - *Significant environmental risks*
  - *Community organization and capability to develop economically-productive uses for the land*
  - *Community and regulator willingness to accept a reasonable cleanup approach*

7. Creating a Stable, $5B/yr Budget for Five Years to Credibly Satisfy DoD Environmental Security Needs

Issues

- *To implement a more efficient and effective environmental security program, budget stability, a long range vision, and metrics to measure program success are critical*
- *Even a stable, $5B/yr budget will be insufficient without process improvement -- both are required*
- *After FY2000 the required dollars should be less -- as a result of the process improvements being fully implemented*

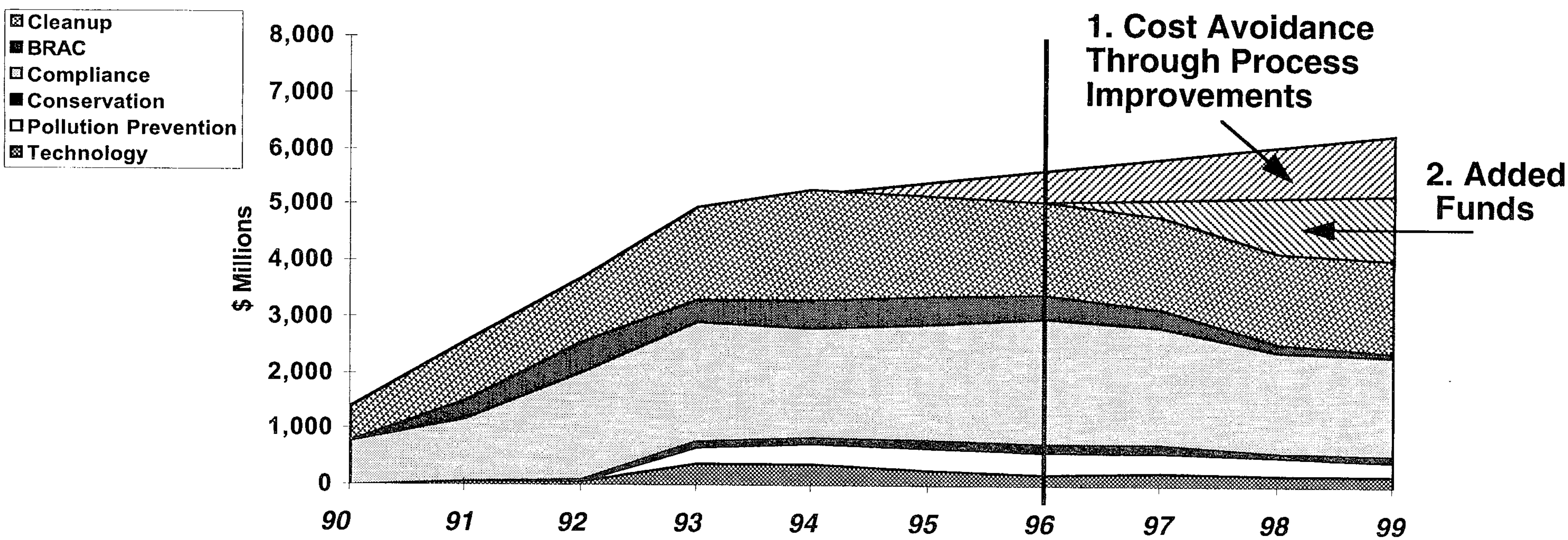
The Budget Dilemma



	90	91	92	93	94	95	96	97	98	99
Cleanup	601	1,065	1,130	1,639	1,965	1,780	1,630	1,630	1,630	1,630
BRAC		304	540	404	526	518	451	325	149	77
Compliance	790	1,108	1,930	2,118	1,921	2,065	2,241	2,119	1,779	1,766
Conservation		10	25	133	132	144	148	139	99	104
Pollution Prevention				274	338	386	370	345	291	257
Technology		77	70	393	411	290	229	257	232	225
Total	1,391	2,564	3,695	4,961	5,293	5,183	5,069	4,815	4,180	4,059

FY96 Proposed budget estimates exclude BRAC-95 and all funding associated with industry costs on weapon systems, which is estimated to be approx. $2B/yr (i.e., 2% of a total annual expenditure of the $100B for R&D, Procurement and Support) -- funding could be lower, based on actions by Congress and/or the Administration

Two-Pronged Approach to a Solution



7. Creating a Stable, $5B/yr Budget to Credibly Satisfy DoD Environmental Security Needs

Recommendations

- ***Stabilize the DoD environmental security budget at the $5B per year level* for five years (FY96-FY2000)***
  - *Includes specific resource allocation recommendations of this Task Force.*
- ***Implement the efficiency and effectiveness recommendations of this Task Force***
  - *In some cases, there will be a need for legislative reform*

** Constant FY1996 dollars*

Conclusions

DoD Leadership in Environment
-To Reduce Costs and Minimize Readiness Impacts -

- *The environment is a major issue for the nation and the DoD and must continue to be incorporated in the mainstream of the DoD's activities and resource allocations*
- *The Task Force sees the potential for the DoD to dramatically improve its environmental security programs*
- *The Task Force believes that the DoD must take a leadership role in those environmental security areas that impact its operations and costs*
  - *Small shifts in DoD's environmental security resources.*
  - *Large shift in cultural perspective and orientation*
- *By showing such leadership and working closely with regulators and community stakeholders, the DoD can put itself in a better position to greatly lower its environmental costs and minimize the environmental impacts on its readiness*
- *To address the need for increased resources to meet DoD environmental demands:*
  - *Implement the process improvement recommendations of this Task Force*
  - *Stabilize environmental security budgets at $5B/yr for the next 5 years (~2% of DoD budget)*

Seven Big Opportunities for Improvement

1. *A management program of cleanup, compliance, prevention and conservation projects based on comparative risk reduction*
2. *Increasing focus on, and investment in, pollution prevention*
3. *Accelerating technology development and deployment*
4. *Integrating environmental considerations into weapons systems life cycles*
5. *Assuring efficient and effective implementation through benchmarking and appropriate metrics*
6. *Developing a DoD proactive focus on natural and cultural resource conservation affecting readiness*
7. *Creating a stable, $5B/yr budget for the next five years to credibly satisfy environmental needs*

DoD Implementation

- ***To implement the Task Force recommendations, the Under Secretary of Defense (Acquisition and Technology) should :***
  - ***Prepare plans for DoD action on each of the seven opportunities for improvement, with milestones and completion dates***
  - ***Periodically (e.g., semi-annually) report progress against these milestones to an independent board***

Appendix A.

Terms of Reference

Terms of Reference

THE UNDER SECRETARY OF DEFENSE

3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

ACQUISITION AND TECHNOLOGY

SEP 0 2 1994

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference -- Defense Science Board Task Force on Environmental Security

You are requested to establish a Defense Science Board Task Force on Environmental Security. The purpose of this Task Force is to undertake a study to investigate areas of technology and/or policy changes that can have a dramatic impact on future Department of Defense (DoD) environmental security in the areas of:

1. Remediation/clean-up (cheaper, faster, better);
2. Pollution prevention (in the design or manufacture/support of current and future weapons); and
3. Measurement (for compliance, conservation and needed action).

The effort should include:

a. A comprehensive review and analysis of existing DoD Environmental Security policies and guidance; the effectiveness of their implementation, e.g., in weapon system development, production, support and disposal, as well as in base and plant closures; the current programs and budgets; and any prior audits, studies and analyses in this area.

b. Compilation of a representative set of historic examples which can be used to convey the nature of the issues involved to the Administration, the Congress, and the general public.

c. Recommendations for strategy, and specific plans of action (including milestones, resources, roles and responsibilities, etc.), to implement a strong Environmental Security program.

While focused on DoD environmental technology efforts, the study should consider currently planned activities related to other agencies, as well as any procedural or legislative issues that could impact rapid and effective Environmental Security program implementation.

The Deputy Under Secretary of Defense (Environmental Security) (DUSD(ES)) will serve as sponsor of this effort, and provide funding and other support as necessary. Dr. Jacques S. Gansler will serve as Task Force Chairman. Mr. Edward J. Dyckman, ODUSD(ES), will serve as Executive Secretary. LTC John Dertzbaugh, USA, will be the Defense Science Board Secretariat representative. The analysis and recommendations should be completed by April 30, 1995; with an interim report due in January 1995.

Noel Longuemare

R. Noel Longuemare
Principal Deputy Under Secretary of
Defense (Acquisition & Technology)

Appendix B.

Briefings Provided to the Task Force

Appendix B.

Briefings Provided to the Task Force

Briefer	***Subject***
Dr. Calvin Vos, Office of General Counsel, DoD*,	*Conflict of Interest*
Ms. Sherri Goodman, DUSD(ES),	*Environmental Security Introductory Remarks*
Mr. Peter Walsh, ADUSD(EQ)	*Defense Environmental Quality Program*
Ms. Patricia Rivers, ADUSD	*Defense Environmental Restoration Program at Active and Closing Bases*
Mr. Patrick Meehan, ODUSD(ES)	*Defense Environmental Security Investment Strategy*
Mr. Robert H. Lucacher, United Defense Ground Systems Division	*Environmental Security Within the Defense Industrial Complex*
Mr. George Siebert, ADUSD(Safety and Occupational Health)	*Defense Safety, Occupational Health, and Fire and Emergency Services Program*
Dr. Daphne Kamley, ADUSD(Environmental Technology)	*Defense Environmental Security Technology Activities*
CAPT Herbert T. Bolton, USN, Armed Forces pest Management Board(AFPMB)	*DoD Pest Management Program*
Dr. Lawrence H. Duboise, ARPA	*ARPA Activities in Environmental Technology*
Dr. Clyde Frank, DoE	*Systems Approach to Environmental Technology Development*
COL William R. Wright, DoD Explosives Safety Board	*DoD Explosives Safety Program*
Mr. Richard Newsome, Secretary of the Army (Environment, Safety and Occupational Health)	*U.S. Army Environmental, Safety and Occupational Health Program*
CDR John Quinn, USN, Office of the Chief of Naval Operations and Mr. Craig Sakai, HQ U.S. Marine Corps	*U.S. Navy and Marine Corps Environmental Protection Program*
Col (Sel) Don Murphy, USAF, Office of the Civil Engineer and Col Robert Perry, USAF, Office of the Surgeon General, U.S. Air Force	*U.S. Air Force Environmental and Occupational Health Program*
Mr. Jan B. Reitman, Defense Logistics Agency (DLA)	*DLA Environment, Safety and Occupational Health Program*
Dr. Jeffrey A. Marqusee, OADUSD(ET)	*DoD Environmental Technology Requirements Strategy*
Ms. Connie VanBrocklin, HQ Department of the Army	*Methodology for Establishing and Ranking Army Environmental Quality Technology Requirements*
Dr. Robert Oswald, U.S. Army Corps of Engineers	*Environmental Quality RDT&E Program and the Strategic Environment Research and Development Program (SERDP)*
Dr. Jeffrey Marqusee	*Environmental Security Technology Certification Program (ESTCP)*
Mr. Marty Faile, Air Force Center for Environmental Excellence	*Bioventing Protocol for POL Cleanup*
Dr. Richard S. Miller, Office of Naval Research	*Environmentally Responsible Life-Cycle Design of Propellants, Explosives and Pyrotechnics*

Briefer	Subject
Ms. Carole Parker, OADUSD(EQ)	*Integrating Environment, Safety and Occupational Health Consideration into the Acquisition Process*
Mr. Michael Anderberg, OSD	*Life-Cycle Cost Estimates for DoD Acquisition Programs*
Mr. Andy Porth, OADUSD(EQ)	*Joint Service Cooperation to Enhance Pollution Prevention at Contractor Facilities*
Dr. Steve Siegel, U.S. Army Concepts Analysis Agency	*Linear Programming Model to Establish Pollution Prevention Funding Priorities*
Dr. Raymond C. Loehr, Hussein M. Alharthy, the University of Texas at Austin	*Beyond the Horizon: Anticipating Tomorrow's Environmental Problems*
COL T.M. Brady, USA, Army Environmental Program, DAIM-ED	*Defense Environmental Security Corporate Information Management (DESCIM)*
Dr. Walter Kovalick, EPA	*Introducing Innovative Technologies into the Marketplace and Regulatory Community*
Col James Owendoff, USAF, ADUSD(Cleanup)	*Risk-Based Management for DoD Environmental Restoration*
Dr. Rita Gregory, Air Force Civil Engineering Support Agency	*RACER Demonstration*
Col Don Murphy, USAF, Office of the Civil Engineer	*Environmental Program Objective Memorandum(POM) Development*
Mr. Barry Breen, Mr. James Edward and Mr. Richard Satterfield, EPA	*Relevant Work From EPA:* *1. Status of Federal Facilities Report* *2. Benchmarking Report in Progress* *3. Environmental Challenge Program*
Mr. Alvin Alm, SAIC	*General Introduction*
Mr. Gary Vest, PADUSD(ES)	*DoD International Environmental Activities*
Ms. Pat Rivers, ADUSD(Cleanup)	*Defense Environmental Restoration Measures of Merit*
Ms. Maureen Sullivan, ODUSD(ES), Compliance	*Defense Environmental Compliance Measures of Merit*
Mr. Peter Boice, ODUSD(ES), Conservation	*Defense Environmental Conservation Measures of Merit*
Ms. Carole Parker, ODUSD(ES), Pollution Prevention	*Defense Pollution Prevention Measures of Merit*
Mr, John Lemke, OADUSD(Safety and Occupational Health)	*Defense Safety and Occupational Health Measures of Merit*
Dr. Jeffrey Marqusee, OADUSD(Environmental Technology)	*Defense Environmental Security Technology Measures of Merit*
CAPT Herb Bolton, USN, ODUSD(ES)	*Defense Pest Management Measures of Merit*
COL Dick Wright, USA, ODUSD(ES)	*Defense Explosives Safety Measures of Merit*
Mr. Jack Mahon and Ms. Kathy Ann Kurke, U.S. Army Corps of Engineers	*Risk and Indemnification Issues in Federal Environmental Restoration Program and Liability and Risk Allocation Issues in Technology Innovation*

Briefer	***Subject***
Mr. Richard Beers, Mr. Richard Russell and Ms. Maryann Gilleece, GEO-Centers, Inc.	*The Relationship of Procurement Practices and the Acceptance of New Environmental Technologies: STOLS Case Study*
Mr. Eugene Berman, Molten Metal Technology	*Developing and Innovating Technology, Catalytic Extraction processing (CEP) Case Study*
Ms. Dorothy Kellogg, Chemical Manufacturers Association (CMA)	*Chemical Industry Environmental Management - Standard Practices and Procedures*
Mr. Dan Kennedy, Bechtel, Inc.	*Defense Industries Environmental Management - Standard Practices and Procedures*
Mr. John Busch, IBIS Associates	*Implementing Environmental Programs in Industry: Automative Industry Case Study*
Dr. George Pinder, University of Vermont	*Life Cycle Cost and System Performance*
Mr. Millard Carr, Office of the Assistant Secretary of Defense (Economic Security)	*Energy Conservation Incentives: A Model for Pollution Prevention Incentives*
Ms. Deborah Jensen, The Nature Conservancy and LtCol Thomas Lillie, USAF, AF/CEVP	*Managing Biodiversity on Military Lands*
Mr. James I. Arnold, Army Environmental Center	*Munitions Waste Technologies: Deployment Problems and Return on Investment*
Dr. Walter W. Kovalick, Jr. EPA	*Remediation Technologies: Deployment Problems and Return on Investment*
Ms. Pat Rivers	*Panel Briefing from Environmental Security Offsite*
Ms. Maureen Sullivan	*Panel Briefing from Environmental Security Offsite*
Ms. Daphne Kamely	*Panel Briefing from Environmental Security Offsite*
Ms. Carole Parker	*Panel Briefing from Environmental Security Offsite*
Mr. Peter Walsh	*Panel Briefing from Environmental Security Offsite*

Appendix C.

Acronyms

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Acronyms

AIRFA	*American Indian Religious Freedom Act*
BRAC	*Base Realignment and Closure*
CAA	*Clean Air Act*
CERCLA	*Comprehensive Environmental Response, Compensation and Liability Act*
CONUS	*Continental United States*
CWA	*Clean Water Act*
CY	*Calendar Year*
CZMA	*Coastal Zone Management Act*
DFE	*Design for the Environment*
DNT	*Dinitrotoluene*
DoD	*Department of Defense*
DOE	*Department of Energy*
DSB	*Defense Science Board*
EIS	*Environmental Impact Statement*
EPA	*Environmental Protection Agency*
EPCRA	*Emergency Planning and Community Right-to-Know Act*
ESA	*Endangered Species Act*
FIFRA	*Federal Insecticide, Fungicide, and Rodenticide Act*
FLPMA	*Federal Land Policy Management Act*
FWCA	*Fish and Wildlife Coordination Act*
FWPCA	*Federal Water Pollution Control Act*
FY	*Fiscal Year*
GPS	*Global Positioning Systems*
HazMat	*Hazardous Materials*
HMTA	*Hazardous Materials Transportation Act*
HSWAA	*Hazardous and Solid Waste Amendments of 1984*
MBTA	*Migratory Bird Treaty Act*
MILSPEC	*Military Specification*
MMPA	*Marine Mammal Protection Act*
MPRSA	*Marine Protection, Research, and Sanctuaries Act*
NANPCA	*Nonidigenous Aquatic Nuismce Prevention and Central Act*
NCA	*National Command Authority*
NDCEE	*National Defense Center for Environmental Excellence*
NEPA	*National Environmental Policy Act*
NHPA	*National Hertoric Preservation Act*

NWPA	*Nuclear Waste Policy Act*
NWRSAA	*National Wildlife Refuge System Administration Act*
ODC	*Ozone, Depleting Chemicals*
OSD	*Office of the Secretary of Defense*
OSHA	*Occupational Safety and Health Act*
PCBs	*Polychlorinated Biphems*
PEO	*Program Executive Officer*
PM	*Program Manager*
POLs	*Petroleum, Oils and Lubricants*
PPA	*Pollution Prevention Act*
PPBS	*Planning Programming, and Budgeting System*
RCRA	*Resource Conservation and Recovery Act*
RDT&E	*Research, Development, Testing and Evaluation*
S&T	*Science and Technology*
SARA	*Superfund Amendments and Reauthorization Act of 1986*
SCAPS	*Site Characterization and Penetrometer Analysis System*
SDWA	*Safe Drinking Water Act*
SERDP	*Strategic Environmental Research and Development Program*
SMCRA	*Surface Mining Control and Redemption Act*
TSCA	*Toxic Substances Control Act*
UMTRCA	*Uranium Mill Tailings Radiation Control Act*
UV	*Ultraviolet*
VOC	*Volatile Organic Compound*
WSRA	*Wild and Scenic Rivers Act*

Appendix D.

Cost Minimization of Groundwater Contamination Remediation at a U.S. Air Force Site Using Optimal Design Software

George F. Pinder, George P. Karatzas, and David P. Ahlfeld, Research Center for Groundwater Remediation Design (RCGRD)

Introduction

The purpose of this report is to demonstrate the impact of the target level of residual risk and the elapsed time to the achievement of this residual risk on the costs of groundwater contamination site cleanup. A secondary purpose is to illustrate the potential savings that can be achieved using optimal design software in the design of pump and treat systems. To assure relevance to the DoD mission, a U.S. Air Force site was selected for investigation. While a pump-and-treat strategy is utilized at this site and therefore in this example, other remediation methods are also amenable to least-cost design methodology. This is a preliminary analysis. The information contained herein is indicative of, but different than, that which would be generated in a more detailed study.[1]

The enormous impact of groundwater remediation on the budget of the DoD requires that a relationship between residual risk and cost be established. Once this information is available, decisions can be made regarding an appropriate level of cleanup at a site. In addition, by comparing similar analyses completed for other contaminated sites, priorities can be set among sites and, as a result, available resources used most intelligently.

In a similar vein, it is important to determine the level of effort to be expended at each site. As will be demonstrated below, the shorter the period of time allowed to achieve the target level of residual risk (or time to compliance), the higher the costs. Thus an analysis between the time permitted to achieve acceptable residual concentrations and project cost is of interest. With this information in hand the trade-off between residual risk and time to compliance at each site can be established and priorities among sites and among design strategies set.

Because groundwater systems are very complex and the cost of acquiring information to characterize them is high, groundwater professionals find it difficult to achieve optimal design strategies for groundwater remediation systems. As will be demonstrated hereinafter, computer software dedicated to assisting the groundwater professional in the pursuit of the most cost-effective remedial design has the demonstrated potential of significantly reducing the cost of groundwater cleanup without increasing the risk to either public health or sensitive environmental areas.

The Problem at the Site

Groundwater was first found to be contaminated with volatile organic compounds in 1979 (see Figure 1). The Air Force site is among the several sources of this contamination. During the next decade numerous studies were conducted in an effort to characterize the contaminant plume and the subsurface soil conditions in the area. The investigations established the existence of two aquifer zones separated by a low permeability layer. In addition a perched-water zone was identified whereat water was impeded from migrating vertically to the regional water table by a low permeability layer.

[1] While water quality information collected on the site was used in the original calibration of a groundwater model of the site in 1986, further model development using more recent information would result in an improved model and therefore a more accurate analysis.

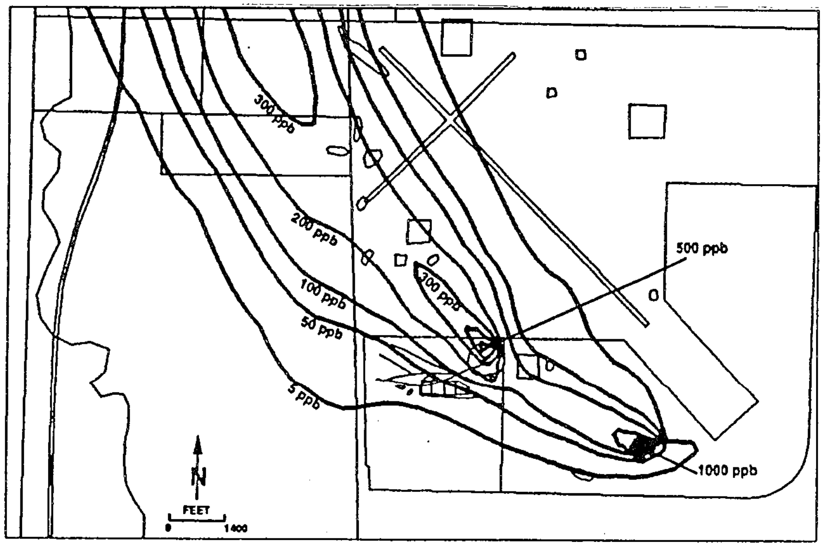

Figure 1: Groundwater Contamination Concentration Distribution As Calculated in 1986

Using the information available at the time, a pump and treat groundwater remediation strategy was formulated and commenced operation in April of 1987 [1]. The in-place well network has 16 extraction wells and 13 injection wells in the upper, most contaminated unit. It is this unit that is the subject of this investigation.

The ultimate objective of the proposed remedial design is to cause the contaminant plume to retract to the point where the concentration at specified measurement locations satisfies, after a specified period of time, the drinking water standards for various chemicals. In the case of trichloroethylene (TCE), which is the chemical considered in this investigation, the highest acceptable residual concentration level at selected locations on and around the site at the end of the cleanup period has been selected as five micrograms per liter. In this particular case the concentration level is consistent with proposed drinking water standards.[2]

Groundwater Containment Behavior

The particular application of least-cost design software demonstrated in this analysis requires the use of a groundwater flow and transport model. Using the information available on the site, one can attempt to use the model to reproduce the distribution of contaminants found in 1993 (see Figure 2). Comparison of the information contained in Figure 2 and that contained in [1] provides insite into the ability of the preliminary groundwater model in this analysis to represent the field situation. In general it is a good representation, but one that could be further improved through additional model development.

[2] In the current phase of this cleanup, the formal legal requirements are reported to us to be containment of the plume. However, any appropriate level of risk can be specified.

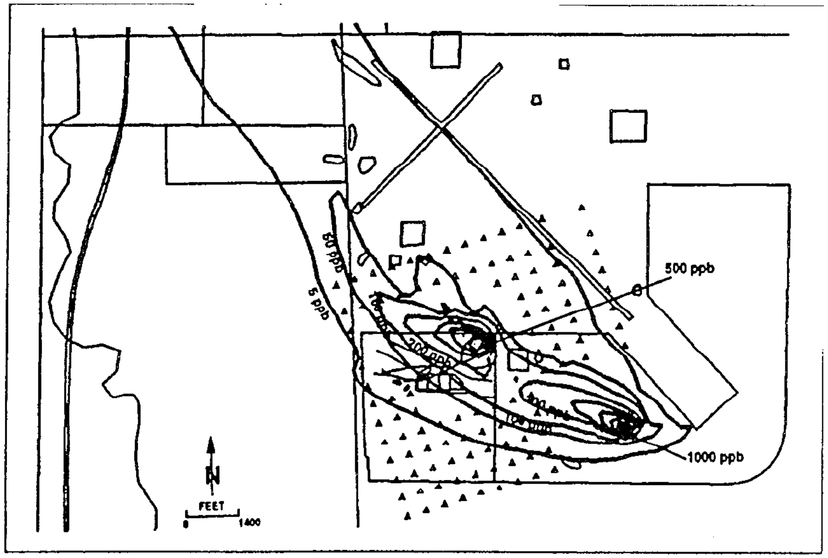

Figure 2: Contaminant Distribution As Simulated for the Year 1993

In this instance the model is used to forecast the behavior of the contaminant plume in response to various remedial designs selected by the computer. It can also be used to illustrate the behavior of the groundwater system in response to an existing, currently employed network of recharge and discharge wells. When the existing well-field design is introduced into the model, after 20 years of pumping the computed contaminant plume topology resultant is as provided in Figure 3.

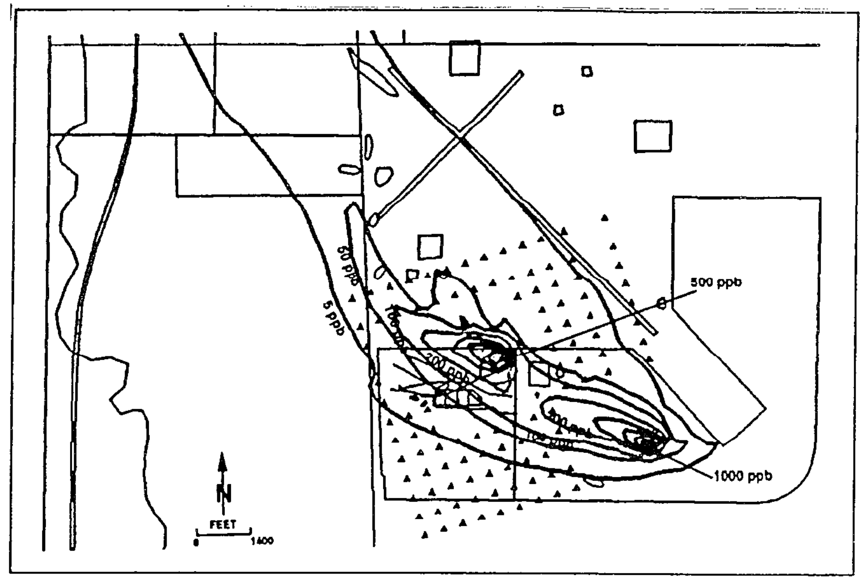

Figure 3: Simulated TCE concentration distribution after 20 years of pumping using the current pump and treat design. The black triangles indicate where the concentration values must respect thsoe required at compliance.

The cost of this pump and treat system at the end of the 20 year period is estimated to be 102 million dollars.[3] The locations and average daily discharge and recharge rates of wells utilized in this design are presented in Figure 4. The foot of the vertical bar indicates the well location and the height of the bar is a relative measure of the discharge or recharge rate.[4] According to the model, the maximum concentration of TCE that would be recorded at

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[3] A zero discount rate is assumed in all calculations made in this report. Information regarding costs was provided on a per unit basis by DoD personnel.

[4] In this analysis it was assumed that the maximum well discharge could not exceed 390 gallons per minute. If geological constraints preclude this level of pumping in some areas the final design should be modified accordingly.

the measurement locations (indicated by the black triangles in Figure 3) after 20 years is 100 micrograms per liter.

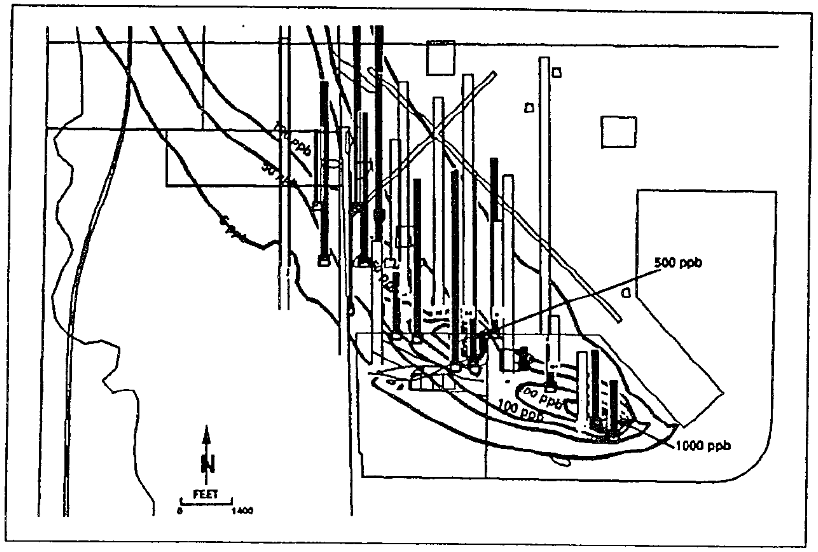

Figure 4: Distribution of discharge (dark) and recharge (light) wells currently employed in the pump and treat design. The height of the bars indicates the relative discharge or recharge at each well location.

An Optimal Design

The remedial design discussed above should represent the best configuration obtainable by the groundwater professional, based upon insight and experience. However, it is not likely to be the least-cost design. To obtain the least-cost design requires a computer assisted approach. The least-cost design strategy calls for using a groundwater model in combination with an optimal design algorithm such as used in operations research. According to this protocol, the computer searches for the least-cost combination of recharge and discharge wells that will satisfy the specified risk-based concentration constraints (water quality standards, for example, at the specified observation points).

The operations research model identifies candidate well network designs which are subsequently evaluated using the groundwater model. The model predicts the effectiveness of the design and feeds this information back into the operations research algorithm. This algorithm examines this response and, learning from it, modifies the original design to make it more cost effective. This procedure is continued until the least-cost design is realized.

In the case of this site, the least-cost design capable of achieving the same level of cleanup as the design generated by the groundwater professional required six wells and cost 17.9 million dollars. This constitutes a net saving of 84.1 million dollars relative to the cost of the currently employed design. The optimal design in this case is achieved using the current well locations and only changing the rate of recharge or discharge. If new well locations could be used, the savings would almost certainly be larger[5]. On the other hand, improvements in the model and the provision of additional information on the site could also result in somewhat lower savings.

The locations and average daily discharges for the wells employed in the least-cost design are illustrated in Figure 5.[6] The analysis presented herein assumes one

[5] It is important to emphasize that this analysis was conducted using a preliminary model and the optimal design generated is sensitive to the ability of the model to represent the physical system.

pumping rate for the entire 30 year period. An alternative strategy would allow variable pumping rates over time. It is, however, possible to modify the well configuration at any point during the cleanup period and rerun the optimal design software to update the design. In computing total costs both the installation and operating and maintenance costs are considered.

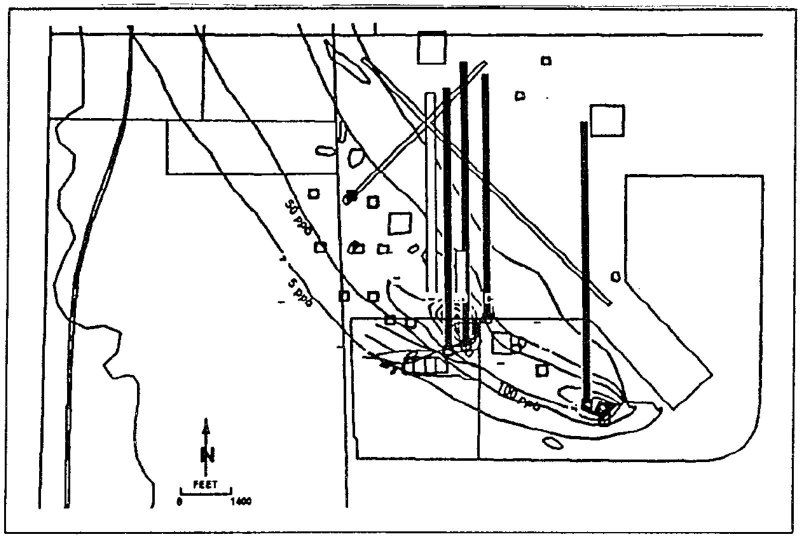

Figure 5: Locations and discharge values for wells obtained from a least -cost design using a residual-risk level of 100 micrograms per liter.

The Relative Cost of Risk Reduction

The preceding section illustrates how appropriate computer software can be used to obtain least-cost designs for remediating contaminated groundwater. Implicit in this analysis was the specification of an acceptable level of residual risk as indicated by target concentration levels at selected observation points and the point in time when these concentration levels were to be realized. Each of these factors has a profound impact on the costs of remediation. Since one can obtain a least-cost design for various combinations of these factors, it is possible to examine the trade-off between each of them and the total cost of remediation. This is clearly important in establishing cleanup priorities.

Consider first the relationship between residual risk and cost. Figure 6 is a plot of the cost of remediation for a 20 year period versus the level of residual risk. For example, if the residual risk at the locations indicated in Figure 4 is specified to be less than 100 micrograms per liter, then the cost for the 20 year pump and treat scenario will be 17.9 million dollars. On the other hand, if a residual risk of 68 micrograms per liter is specified, the 20 year remedial costs will be 29.4 million. Using results obtained for two other residual concentration constraints, the curve found in Figure 6 is generated.

The curve in Figure 6 demonstrates that the cost of reducing risk is not a constant. As greater risk reduction is demanded, the cost of each additional increment of risk reduction goes up. Indeed, it was not possible to find a design that would reduce the concentration below 68 micrograms per liter using the well field currently in place.[7] This is very important information to have since it avoids wasting the time of the groundwater professional is searching for a physically impossible design.

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[6] The approximate location of the contaminant plume at the end of the 20 years of remediation is also provided.

[7] In all of the above analyses, it is assumed that the source of contamination remains active. If the sources are effectively removed, the least-cost design would change but the general conclusions drawn from the investigation would be essentially the same as presented here.

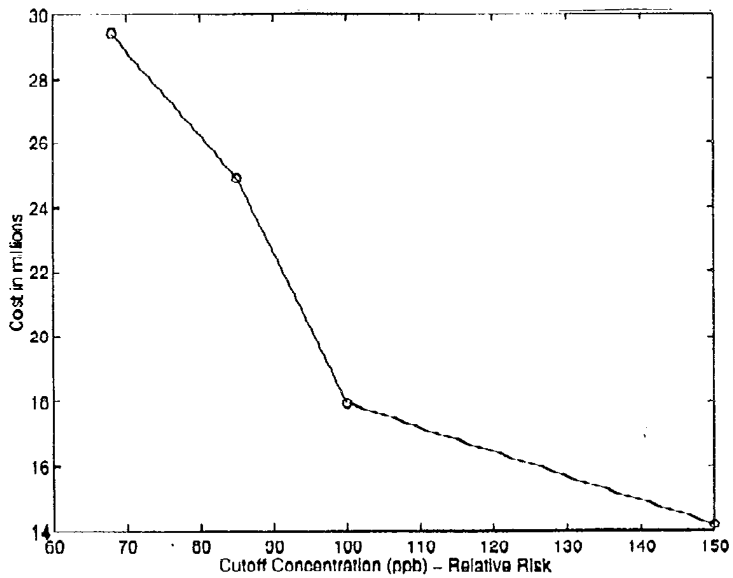

Figure 6: Relationship between residual risk (using residual concentration levels at specified locations as a surrogate for risk) versus the cost of achieving the target risk levels. A zero discount rate is assume. The period for compliance is taken as 20 years.

In the above analysis of the cost of residual risk reduction, we assumed the target concentrations had to be achieved in 20 years. However, if this period is modified, the costs of remediation will change.

Let us assume that the acceptable level of residual risk is 100 micrograms per liter. Given this target concentration, one can examine the costs of achieving it over various time periods. In Figure 7 is plotted the cost of remediation at the end of thirty years versus the period of time at which this target concentration must be achieved.

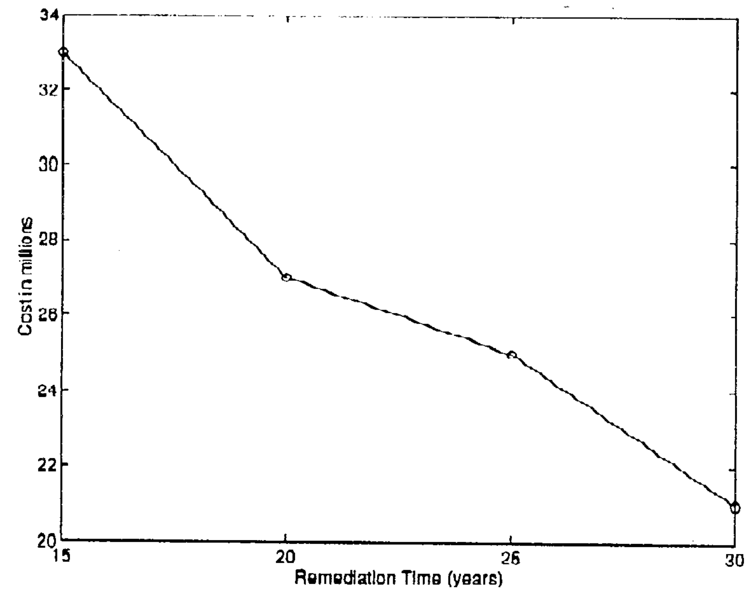

Figure 7: Period of time to compliance versus the cost of achieving a residual risk level of 100 micrograms of TCE per liter.

Figure 7 demonstrates that the shorter the time period allowed for compliance, the higher the overall costs become. This is due to the fact that shorter compliance times require more pumping which, in turn, requires more wells pumping at higher rates. As in the case of the residual risk constraint, there is a minimum period of time required to achieve compliance with a given set of possible well locations. In this case it appears to be approximately 15 years. In other words, to achieve compliance in less than 15 years it would be necessary to add new well locations to the set of possible well locations made available by the groundwater professional to the least-cost design software. No matter what period of time is postulated to achieve compliance, consideration must be given to any contaminants which

may remain suspended in the soil above and adjacent to the aquifer. These can be a continuous source of contaminant replenishment long beyond the time compliance levels are achieved and may, therefore, necessitate continued pump and treat operations for an indeterminate period beyond achievement of compliance.

Conclusions

The costs associated with the remediation of groundwater contamination can be substantially reduced through the use of least-cost design software as an aid to the groundwater professional. Taking a U.S. Air Force site as an example, total costs over a twenty year period were reduced by 84.1 million dollars or 82.5% of the current in-place design costs. Of course the cost reduction achievable at other sites will vary.

The cost of reducing residual risk increases as lower risk levels are demanded. As the minimum achievable risk level is approached, each additional increment of improvement becomes very expensive. This was clearly evident in the analysis of this site.

The cost of accelerating cleanup is significant. As the period for compliance is reduced, the costs for compliance increase. Thus longer cleanup times tend to be less expensive, assuming all of the pump and treat systems remain operational for the same period of time.[8]

[8] In the case of this example, this minimum time of pumping was taken, somewhat arbitrarily, to be 30 years. If the sources are not effectively removed, a perpetual care situation results and pumping would continue indefinitely unless methods other than pump and treat are employed.